HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

SUSTAINABLE DEVELOPMENT GOALS

REPORT ON THE SUSTAINABLE DEVELOPMENT GOALS

REPORT 2024

Contents

Executive Summary

The United Nations General Assembly adopted the 2030 Agenda for Sustainable Development in 2015, guided by the principle of *"leaving no one behind."* This global framework comprises 17 Sustainable Development Goals (SDGs) that collectively aim to transform the world by eradicating poverty, promoting social inclusion, ensuring environmental sustainability, and advancing peace, good governance, partnerships, and economic prosperity for all nations and peoples.

This Sustainability Report 2025 of the Hungarian University of Agriculture and Life Sciences (MATE) underscores the University's commitment to the SDGs. The report captures MATE's progress toward its sustainability objectives and showcases transformative initiatives implemented in collaboration with faculty, students, staff, and community partners over the past year. It highlights the diverse range of research, innovation, and educational activities through which the University contributes to the achievement of the global goals.

Each SDG section highlights relevant research and education-related indicators, based on Elsevier's 2022 SDG Mapping methodology and adapted to MATE's institutional context. This localized approach provides a more accurate representation of the University's unique contributions to sustainable development within Hungary, across Central Europe, and in the broader international sphere.

About MATE

On February 1, 2021, the Hungarian University of Agriculture and Life Sciences (MATE) was established through the integration of eleven research institutes and companies of the National Agricultural Research and Innovation Centre, together with the Agricultural Research Institutes of the University of Debrecen and the Research Institute of Karcag (**Figure 1**). As a result, MATE has evolved into far more than a traditional university — it is a comprehensive hub for education, research, innovation, and practical development within the agricultural and life sciences sectors.

Figure 1. The campuses of the Hungarian University of Agriculture and Life Sciences

University Impact Rankings for the SDGs

The 17 Sustainable Development Goals (SDGs), established by the United Nations in 2015, define a global framework for eradicating poverty, reducing inequalities, protecting the planet, and ensuring prosperity for all by 2030. Aligned with this vision, the Times Higher Education (THE) Impact Rankings, launched in 2019, assess how universities worldwide contribute to the SDGs through their research, teaching, outreach, and institutional practices. The Hungarian University of Agriculture and Life Sciences (MATE) actively participates in this global evaluation, focusing on six priority goals that reflect its academic strengths and societal mission: SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), SDG 15 (Life on Land), and SDG 17 (Partnerships for the Goals). Through its targeted research, community engagement, and sustainable operations, MATE demonstrates measurable impact in these domains.

As the largest agricultural university in Hungary, the Hungarian University of Agriculture and Life Sciences (MATE) is deeply committed to advancing sustainable development, a commitment reflected in its performance

in the Times Higher Education Impact Rankings. From the outset, MATE achieved a position in the 401–600 range, placing it among the top 25% of ranked universities worldwide - an outstanding accomplishment among Hungarian institutions. In 2025, MATE earned the third-highest national ranking out of twelve participating universities.

In the 2024 Times Higher Education Impact Rankings, a total of 2 318 universities were evaluated globally. MATE's participation across these selected SDGs underscores its commitment to sustainability, knowledge transfer, and evidence-based solutions that address the most pressing global challenges while advancing Hungary's leadership in agricultural, environmental, and socio-economic research.

Figure 2 presents MATE's performance across the Sustainable Development Goals (SDGs) relevant to this ranking. The analysis served as a strategic foundation for identifying priority areas for the 2026 THE Impact Rankings submission. Building on these insights, MATE continues to report and provide detailed data for SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), and SDG 15 (Life on Land), alongside the mandatory SDG 17 (Partnerships for the Goals). This integrated approach reflects MATE's enduring commitment to sustainability and its mission to address global challenges through research, education, and innovation.

THE

Sustainable Development Goal	Our Rank 2024
Overal Ranking for Impact	401 - 600
2 Zero Hunger	35
6 Clean Water and Sanitation	201 - 300
8 Decent Work & Economic Growth	101 - 200
15 Life on Land	101 - 200
17 Partnerships for the Goals	101 - 200

QS

Ranking Category	Our Rank 2024
Overal Ranking for Impact	607
1 Employability & Opportunities	1001+
2 Equality	501
3 Knowledge Exchange	1001+
4 Social Impact	808
5 Impact of Education	1001+
6 Environmental Sustainability	693
7 Environmental Impact	544
8 Governance	565
9 Health and Wellbeing	734
10 Environmental Education	556
11 Environmental Research	856

MATE's sustainability achievements are further affirmed by its remarkable progress in the Quacquarelli Symonds (QS) Sustainability Rankings. In the 2025 edition, which evaluated 1 751 higher education institutions worldwide, MATE advanced more than 600 places, from the 1201+ band to the 607th position globally, securing a place among the top 35% of ranked universities. Within Hungary, MATE achieved the fifth-highest position among the twelve institutions included in the ranking. This outstanding performance reflects the university's active implementation of its 2030 Strategy, emphasizing environmental and economic sustainability, responsible governance, and global impact.

Research Contribution of MATE

According to Scopus data, between 2020 and 2024 MATE researchers produced more than 4 700 publications, with over 51% involving international collaboration and 30% national cooperation. While the overall publication growth rate has stabilized in recent years, the share of articles published in Q1 and Q2 journals has continued to rise, a trend expected to persist. The field-weighted citation impact (FWCI), a key indicator of research influence, showed a temporary decline from 1.32 to 1.05 between 2020 and 2022, followed by a recovery to 1.29 by 2024. **Figure 3** illustrates the main research topics and clusters to which MATE's scholars have made significant contributions over this period.

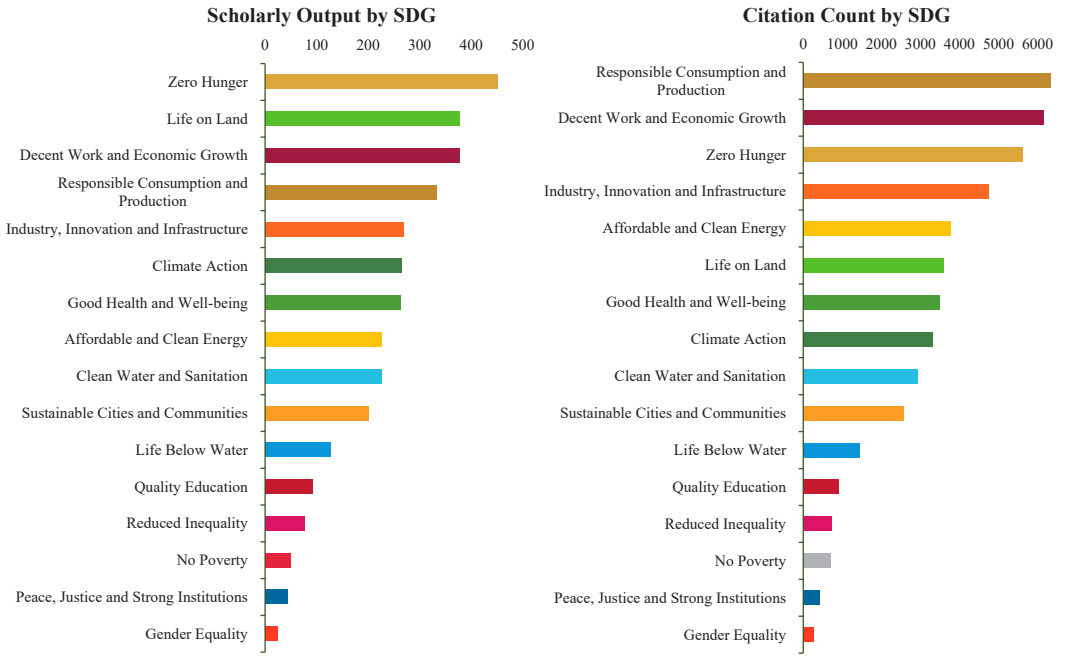


Figure 2. Publication performance of MATE between 2020 – 2024

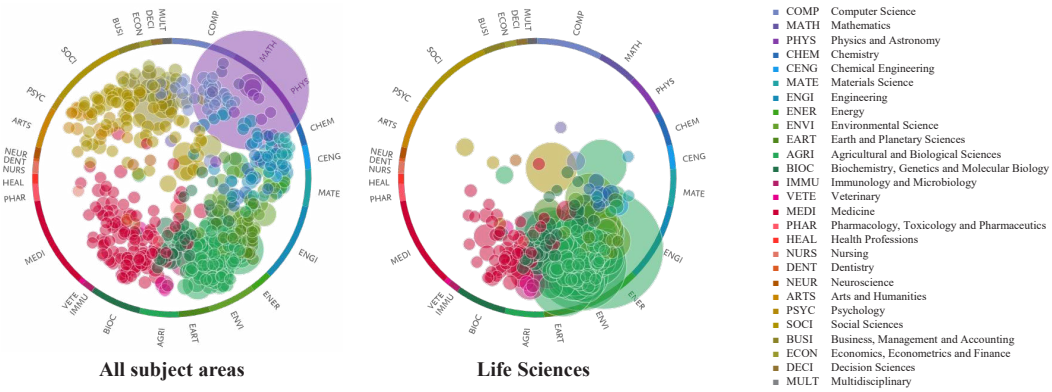


Figure 3. Elsevier ASJC categories to which MATE has contributed between 2020 – 2024

SDG 1

No Poverty

At the MATE, we view Sustainable Development Goal 1 (SDG 1), "No Poverty," as a fundamental cornerstone of our commitment to sustainable agriculture and rural development. Agriculture is a key sector in Hungary and ensuring that rural communities thrive without facing poverty is central to our mission. We recognize that poverty in rural areas can be particularly challenging, with issues such as limited access to education, healthcare, and economic opportunities. To address this, our institution is dedicated to research, education, and outreach programs that empower rural communities, support sustainable farming practices, and promote equitable access to resources both within and beyond our borders. By fostering an interdisciplinary research environment, we aim to target poverty alleviation, economic resilience, and resource accessibility, ultimately addressing critical areas such as income inequality and enhancing social equity on a global scale. We believe that by tackling the root causes of poverty and fostering economic growth in rural areas, we can play a vital role in achieving SDG 1 while simultaneously contributing to a more resilient and sustainable agricultural sector for the benefit of all Hungarians.

17
Publications

88
Citations

Key 2024 Research Contributions to SDG 1

MATE continues to strengthen its contribution to SDG 1 through evidence-based research that integrates social innovation, sustainable entrepreneurship, and resilient agricultural systems. Our 2024 publications illustrate how interdisciplinary research can address the complex economic, environmental, and social dimensions of poverty.

Dr. Zoltan Lakner and Dr. Mária Fekete-Farkas, both from the Institute of Agriculture and Food Economics, conducted extensive investigation into social entrepreneurship as a strategic mechanism for poverty alleviation and sustainable development. Their study, *"Addressing Poverty through Social Entrepreneurship for Sustainable Development: A Comprehensive Bibliometric Analysis"*, systematically mapped global research

trends and identified four key thematic areas; social innovation, entrepreneurial ecosystems, inclusive growth, and sustainable entrepreneurship that are key to driving systemic socio-economic transformation and sustainable livelihoods (Md. T. Miah et al., 2024b).

Another key research was by Dr. Ágoston Temesi, from the same institute, demonstrating how sustainable agricultural practices can reduce poverty among rural populations, through awareness, training, and financial incentives which enable farmers, especially smallholders, to adopt circular-economy practices that stabilize farm income, improve productivity, and mitigate the risks associated with climate change (Hilmi et al., 2024).

Further strengthening the university's research focus on socio-economic sustainability, Dr. István Dedák and Dr. Noémi Fiser analysed the structural transformation of Hungary's pension system in their study *"Pension Reforms in Hungary: Have They Gone Too Far?"*. By comparing reform trajectories across Central and Eastern European countries, the research evaluates the consequences of policy shifts on social welfare and fiscal sustainability. The authors conclude that recent Hungarian reforms, rather than enhancing long-term stability, have weakened elements of the social care framework and increased vulnerability among low-income pensioners emphasizing the necessity of automatic adjustment mechanisms and equitable pension indexation to maintain social protection and prevent old-age poverty (Dedák and Fiser, 2024).

Collectively, these researches along with other studies such as those on digital financial inclusion for women, household resilience to food insecurity, borrowers' financial behaviour, infrastructure development, pension reform and social protection, agricultural management transfers, energy poverty reduction, and the nexus between environmental change and conflict, illustrate MATE University's holistic contribution to ending poverty in all its forms. Through these diverse yet interconnected areas of research, the university demonstrates its commitment to fostering inclusive growth, enhancing resilience among vulnerable communities, and advancing the broader objectives of sustainable development.

Empowering the Future of Organic Farming: The ETICOF Project

Launched in June 2023, the ETICOF Project (Education, Training and Innovations in Conversion to Organic Farming) brings together universities and experts from Slovakia, the Czech Republic, Germany, and Hungary to shape the future of sustainable agriculture. Supported by the Erasmus+ Programme, this three-year initiative focuses on helping farmers and students navigate the complex process of transitioning to organic farming.

With MATE as one of its key partners, ETICOF is developing innovative educational materials, methodological guides, and a comprehensive training curriculum that blend scientific knowledge with farmers' real-world experiences. By promoting practical skills, lifelong learning, and sustainable farming methods, the project directly supports rural communities, improving their livelihoods, and fostering resilient, environmentally conscious agricultural practices for the next generation.

Dr. István Dedák

At the Hungarian University of Agriculture and Life Sciences, we view Sustainable Development Goal 1 (SDG1), "No Poverty," as a fundamentally important field of economic and social sustainability. Although poverty has many social aspects, the situation of the elderly and the sustainability of pension systems stand out among them. As a result of adverse demographic trends, the sustainability of pension systems and the prevention of old-age poverty have come under dual pressure in developed countries. The combination of low birth rates and rising life expectancy has posed unprecedented challenges to the financing of pension systems. Research conducted at MATE, in line with the SDG1 objective, serves both the theoretical foundation and the practical implementation of reform measures essential for the sustainability of pension systems and the prevention of old-age poverty. The results of these studies have been published in leading international journals (Q1, Q2).

Prof. Dr. Mária Farkasné Fekete

The first core objective of the UN's 17 Sustainable Development Goals is the global eradication of extreme poverty by 2030. Two papers presented here represent the related researches at our university showing new approaches to poverty reduction: entrepreneurial solutions create economic opportunities and adoption of the resilience concept for building institutioal interventions to ensure that vulnerable households can cope with shocks and improve their living conditions. The first paper "Addressing Poverty through Social Entrepreneurship for Sustainable Development" presents a comprehensive bibliometric analysis in the field of social entrepreneurship and poverty alleviation to explain the current state, geographical performance, and future research agenda. The second paper "Determinants of household resilience to food insecurity: A case of rural northern Ethiopia by using the RIMA approach" provides a practical framework for household resilience to food insecurity, utilizing the Resilience Index Measurement and Analysis (RIMA) model. Four resilience pillars were examined: access to basic services (ABS), adaptive capacity (AC), Assets (ASS), and social safety nets (SSN). The results outline a clear path for reducing poverty by strengthening the ability of vulnerable populations to endure and recover from shocks. The methodologies used can also be used for research on other SDGs.

SDG 2

Zero Hunger

Sustainable Development Goal 2, "Zero Hunger," is the Hungarian University of Agriculture and Life Sciences' most significant commitment, resonating deeply with our mission and expertise. Agriculture is at the heart of our institution, and we recognize that it plays a pivotal role in addressing hunger and food security challenges. We are committed to advancing sustainable farming practices, pioneering agricultural research, and fostering education that enhances food production while protecting the environment. Through outreach initiatives, we strive to boost agricultural productivity, optimize food distribution, and raise nutritional awareness. By equipping future generations with the knowledge and skills to address global food security, we actively support the achievement of SDG 2. Our collaborations with international partners and local stakeholders drive innovative solutions to eliminate hunger, extending our impact far beyond Hungary's borders.

Key 2024 Research Contributions to SDG 2

Ensuring food security and sustainable agriculture stands at the core of our university's mission and research strategy. Through interdisciplinary collaborations and innovative solutions, our researchers are actively contributing to SDG 2 by addressing the interconnected challenges of agricultural productivity, food quality, environmental resilience, and nutrition. The university's research efforts span from developing climate-smart and resource-efficient farming systems to exploring novel food sources and understanding consumer behaviour in evolving food environments.

113
Publications

392
Citations

In 2024, our university expanded its research portfolio with key research initiatives aimed at strengthening food security across the entire value chain. From the Institute of Animal Husbandry Sciences, researchers explored sustainable feed production using insects as alternative protein sources for livestock and aquaculture, offering an environmentally friendly solution to reduce reliance on traditional feed crops and to alleviate

pressure on natural resources (Hancz et al., 2024). Complementing these efforts, the Institute Horticultural Sciences conducted studies on indoor optimizing artificial lighting strategies for the cultivation of lettuce and microgreens in controlled environments. This research supports the development of resource-efficient urban food systems, enabling the production of nutrient-rich crops close to consumers while minimizing land and water use.

The development of precision agriculture and horticulture technologies continues to be a central focus of our university's research on sustainable food systems. By integrating advanced sensors, remote imaging, and machine learning models, researchers from the Institute of Agronomy are improving the prediction of crop yield and quality under varying environmental and meteorological conditions. For instance, the use of NVDI-based imaging to forecast winter wheat yield enhances data-driven decision-making in crop management, supporting higher productivity and climate-resilient farming. Similarly, the Institute Horticultural Sciences studied machine learning applications in tomato cultivation enabling accurate prediction of key quality traits such as lycopene content, sweetness, and colour, allowing farmers to optimize cultivar selection and cultivation practices. Together, these innovations not only promote efficiency and sustainability in agricultural production but also strengthen the resilience and nutritional quality of food systems in the face of climate change and global population growth.

Beyond production, the university's research also addresses the broader dimensions of food security and consumer resilience under crisis conditions. In 2024, researchers from the Institute of Agricultural and Food Economics examined food supply chain disruptions during the COVID-19 pandemic, revealing how fluctuations in food access, pricing, and consumer stress shape consumption patterns. These insights provide valuable guidance for developing policies that enhance crisis preparedness and supply chain stability. At the same time, the Institute of Rural Development and Sustainable Economy advanced research on climate-smart agriculture in sub-Saharan Africa, emphasizing the integration of indigenous knowledge and sustainable adaptation practices to reinforce traditional farming systems against the impacts of climate variability.

Collectively, these research efforts reflect an integrated approach to achieving SDG 2, linking technological innovation, sustainability, and social resilience to build equitable, efficient, and secure global food systems.

The KÁN University Days 2024

The university once again brought agriculture to life during the 16th KÁN University Days, held from September 27–29, 2024, in Kaposvár. Attracting nearly 40 000 visitors, the event showcased how science, innovation, and tradition unite to advance SDG 2 – Zero Hunger. Over three inspiring days, MATE transformed its campus into a vibrant hub of sustainable food systems. From precision animal husbandry and plant production to fisheries and digital farming, professional forums and live demonstrations revealed how robotics, data analytics, and automation are redefining agriculture. "Agriculture today is a high-tech sector built on traditional knowledge," emphasized Rector Dr. Csaba Gyuricza, encapsulating the event's spirit.

The Hungarian Livestock Breeders' Association, local producers, and students joined forces to promote healthy, sustainable diets through the MA-HAL National Fish Cooking Competition, the Street of Local Flavors, and interactive showcases featuring breeding animals and emerging technologies. Thousands of young visitors engaged with hands-on learning opportunities, nurturing the next generation of agri-innovators. By blending research

excellence, community participation, and celebration, KÁN University Days 2024 reaffirmed MATE's leadership in building a resilient and sustainable food future, where knowledge truly feeds the world.

Prof. Dr. Zoltán Pék

This study applies machine learning models (XGBoost and ANN) to predict key processing tomato fruit quality traits (Brix, lycopene content, and colour) from environmental and meteorological data, supporting data-driven precision agriculture. By improving the accuracy of quality predictions, the research contributes to more efficient crop selection and management, enhancing food quality and reducing waste. The integration of climate and soil data into predictive models aligns with sustainable farming practices, helping farmers adapt to changing environmental conditions. These innovations support SDG 2 by promoting resilient agricultural systems and increasing productivity without compromising nutritional value. Ultimately, the findings offer scalable tools for optimizing tomato production, contributing to food security and sustainable development.

Dr. Zsolt Zalán

Biological control represents a promising technology for combating spoilage-causing and mycotoxin-producing molds, with minimal impact on the quality and nutritional value of agricultural crops and food products. In collaboration with Southwest University in China, we are investigating safe strains of lactic acid bacteria isolated from fermented foods and our immediate environment. These bacteria effectively inhibit mold growth and suppress the production of mycotoxins—including sterigmatocystin, aflatoxin, and patulin—and, when these toxins do occur, they can degrade or bind them. We also validate the efficacy of these bacterial strains in situ, thereby developing a biological control strategy that reduces chemical usage and sustainably mitigates food and feed spoilage. This approach contributes to minimizing agricultural waste and increasing the availability of food for human consumption, thereby supporting the achievement of Sustainable Development Goal 2 (SG2).

Prof. Dr. Eszter Nemeskéri

In order to feed the growing population, as the amount of cultivatable agricultural land is decreasing, due to urbanisation and global warming, the sustainable food production is becoming essential even in cities. Indoor vertical farms offer a solution for the increasing food demand, where the closed-system, soilless cultivation with controlled nutrient supply and water consumption ensures healthy product without chemicals all year round. One advance of vertical farming is that microgreens grown in a given area can be produced with a higher nutritive product than mature plants grown using traditional methods. Microgreens are young, immature plants that are harvested a week after germination. During their development, the accumulation of bioactive substances (vitamin C, vitamin E, beta- carotene, anthocyanins etc.) is significantly influenced by the type of lighting, wavelength composition and combination. We found that during the development of baby leaf lettuce, broad-spectrum white LED lighting (WL) had a favourable effect on leaf chlorophyll content and plant size and thus on fresh biomass yield, but that the addition of UV light (WL+UV) had a negative effect. The results obtained with LED lighting affecting the physiological processes of baby leaf lettuce are currently being tested to increase the nutritional value of other microgreens in vertical cultivation.

Dr. Madarász Balázs

The effects of conservation tillage (CT) on soil properties and erosion have been investigated since 2003. Multivariate analyses are essential for identifying indicators that adequately characterise changes in soil health. Long-term observations have shown that some soil properties, such as cation exchange capacity and base saturation (important soil physical and chemical parameters), improve only gradually over many years, whereas others respond more rapidly and are sensitive to CT practices even in the short term, including water-extractable organic carbon, amino-nitrogen, water-stable aggregates, available phosphorus and potassium, and the photometric characteristics of WEOM. It is particularly important to identify these responsive parameters for short-term research projects, where the early detection of soil improvement processes is essential.

SDG 3

Good Health and Well-being

Recognizing the critical role that health plays in sustainable development, the Hungarian University of Agriculture and Life Sciences is dedicated to advancing Sustainable Development Goal 3, "Good Health and Well-being." Our institution operates at the intersection of agriculture and life sciences, emphasizing the importance of enhancing food production while also prioritizing the health and well-being of individuals and communities. We understand that a sustainable food system is essential for achieving good health outcomes, and our research, education, and outreach initiatives are strategically designed to support this objective. Through innovative agricultural practices, nutrition education, and interdisciplinary collaborations, we strive to improve access to nutritious food and promote overall well-being, both locally and globally. By aligning our efforts with SDG 3, we aim to foster a healthier and more sustainable world, acknowledging that the health of individuals is intricately connected to the health of our planet.

Key 2024 Research Contributions to SDG 3

In 2024, researchers at MATE and their collaborating partners made significant progress toward achieving SDG 3, advancing knowledge on human, environmental, and public health across multiple scientific disciplines. Their collective work reflects a holistic vision of well-being that extends from molecular insights in the laboratory to ecosystem and policy-level solutions shaping healthier futures.

61
Publications

342
Citations

Research on natural compounds brought fresh perspectives to chronic disease prevention. The study *"Silymarin and Inflammation: Food for Thoughts"* revealed how silymarin and silibinin regulate inflammatory pathways and oxidative stress, helping to counteract the mechanisms driving metabolic and degenerative diseases (Surai et al., 2024). Complementing this, the narrative review from Institute of Food Science, *"Metabolic Syndrome and Biotherapeutic Activity of Dairy (Cow and Buffalo) Milk Proteins and Peptides"* examined how bioactive dairy peptides may miti-

gate obesity and metabolic syndrome, underlining the powerful link between nutrition and preventive healthcare. Together, these studies echo SDG 3's call to reduce non-communicable diseases through innovation and healthy lifestyles.

From human physiology, the research lens widened to the environment, where public health meets planetary health. The study by the Institute of Technology, *"Mechanisms of Diffusion of Radon in Buildings and Mitigation Techniques"* offered practical engineering solutions to curb indoor radon exposure, addressing the goal of reducing illness and mortality from hazardous substances. Meanwhile, *"Emerging Ecological Trends in West Africa"* uncovered how restoring soil organic matter and fertility revitalizes ecosystems, enhances food security, and strengthens community resilience: a reminder that environmental stewardship is inseparable from human well-being.

At the Institute of Aquaculture and Environmental Safety, the creation of the World of Crayfish™ platform and the study on *"Diversity and Distribution of Aphanomyces astaci"* contribute to ecosystem and water quality monitoring, enabling rapid detection of aquatic pathogens that threaten biodiversity and food safety. Parallel work by Institute of Horticulture and Institute of Rural Development and Sustainable Economy on spent mushroom compost reuse and farming practice variability demonstrated how circular resource use and sustainable soil management reduce dependence on chemical inputs, promoting cleaner environments and healthier food systems.

These research efforts illustrate the university's multi-faceted approach to SDG 3, from combating chronic and environmental diseases to enhancing resilience, inclusivity, and the foundations of a healthier planet. Each discovery strengthens the university's enduring commitment to fostering well-being for people and ecosystems alike through science, innovation, and partnership.

Keep Young and Fit: Building a Healthier Generation Across Borders

Launched in 2024, the Keep Young and Fit (KYF) project brings together partners from Hungary and Slovenia, including the Hungarian University of Agriculture and Life Sciences (MATE), to take a fresh approach to youth health.

At a time when sedentary lifestyles and poor nutrition are growing concerns, the project aims to help young people build healthier habits through education, prevention, and community engagement. With full funding of €449,430.60, KYF focuses on improving well-being on both sides of the border by developing an innovative health education and development model tailored to young people's needs.

Researchers and educators at MATE are working with schools, municipalities, and healthcare centres to design interactive programs that promote physical activity, mental well-being, and long-term lifestyle awareness.

By equipping young people with the knowledge and confidence to care for their health, Keep Young and Fit supports SDG 3 – Good Health and Well-being, laying the foundation for a stronger, more active generation.

Active Ageing: Nutrition Innovation for Healthier, Longer Lives

In 2024, MATE University, in partnership with Caprioovus Ltd. and Semmelweis University, embarked on an exciting new journey to rethink how food supports healthy ageing. The project "Development of Age- and Condition-Specific Functional Foods with a Focus on Active Ageing" explores how science-driven nutrition can help people stay active and well throughout life.

With funding of over 636 million HUF, the team is developing egg protein–based functional foods that are lactose- and milk protein-free, rich in essential amino acids, and easily digestible. These products are designed for everyone—from children and athletes to older adults—offering tailored nutritional support for different life stages.

By combining food science, health research, and sensory innovation, MATE's researchers are creating delicious, functional foods that do more than nourish, they promote vitality, recovery, and longevity.

This forward-thinking project is a shining example of how MATE advances SDG 3 – Good Health and Well-being, transforming everyday nutrition into a foundation for active, healthy living at every age.

Prof. Dr. András Koris

The research on the biotherapeutic activity of dairy milk proteins and peptides directly supports SDG 3: Good Health and Well-being, particularly its target to reduce premature mortality from non-communicable diseases (NCDs) like metabolic syndrome. The study highlights that bioactive peptides derived from cow and buffalo milk may offer natural alternatives for managing conditions such as hypertension, high blood glucose, and obesity, which are key factors of metabolic syndrome. This aligns with the Hungarian University of Agriculture and Life Sciences (MATE)'s research profile, which emphasizes the critical role of a sustainable food system in achieving positive health outcomes. By exploring functional food components that can mitigate diet-related NCDs, MATE contributes to both agricultural innovation and public health improvement, fostering a healthier and more sustainable world.

Zsombor Márk Bányai

Recent research has focused on developing the *World of Crayfish*™, an open-access global database that compiles distribution data of freshwater crayfish and their pathogens (including *Aphanomyces astaci*, the agent of crayfish plague). Accurate and up-to-date mapping of these species supports the management of freshwater ecosystems and helps prevent biodiversity loss. Since healthy aquatic environments are essential for clean water resources and food security, this work indirectly contributes to human well-being and sustainable health. Thus, the study aligns with the UN Sustainable Development Goal 3 — *Good Health and Well-Being* — by promoting ecosystem health as a foundation for human health.

Zsófia Molnár

The study titled "The Possible Role of Mycotoxins in the Pathogenesis of Endometrial Cancer" was conducted through a collaboration between the Department of Obstetrics and Gynecology at Semmelweis University and the Department of Animal Biotechnology at the Hungarian University of Agriculture and Life Sciences. It was funded by the Hungarian National Laboratory Project, grant number RRF-2.3.1-21-2022-00007, under the Agribiotechnology and Precision Breeding for Food Security National Laboratory.

This report aims to shed light on the potential role of various mycotoxins in the development of endometrial cancer, in alignment with SDG 3' s focus 3. 4. 3.4.1 on mortality rates attributed to cardiovascular disease, cancer, diabetes, or chronic respiratory disease, and 3. 9 on reducing deaths and illnesses caused by hazardous chemicals, air, water, and soil pollution. Mycotoxins are secondary metabolites produced by mold. Their presence in the food chain poses significant risks due to their toxic effects, such as carcinogenicity, genotoxicity, hematotoxicity, and fertility issues. Endometrial cancer is one of the most common types of cancer among women, and its development is influenced by a wide range of factors, including environmental exposures and dietary habits.

We analyzed blood serum and endometrial tissue samples from participants with diagnosed endometrial cancer for various mycotoxins and their metabolites, including total aflatoxins (Afs), deoxynivalenol (DON), ochratoxin- A (OTA), T2- toxin and HT2 toxin, zearalenone (ZEN), alpha- zearalenol (-ZOL), and fumonisin B 1 (FB 1).

Our results revealed a significant correlation between elevated levels of Afs and ZEN and the presence of endometrial carcinomas. Additionally, except for FB 1, we observed higher toxin concentrations in endometrial tissue compared to serum. These findings support further investigation into the link between specific mycotoxins and endometrial cancer, considering the influence of mycotoxins and dietary factors on the disease' s development.

SDG 4

Quality Education

The Hungarian University of Agriculture and Life Sciences (MATE) holds a profound appreciation for Sustainable Development Goal 4, "Quality Education." As a leading institution in agricultural and life sciences education in the region, MATE recognizes education as the cornerstone of progress and development, serving as a fundamental catalyst for a sustainable future. Our commitment to delivering high-quality education fosters a learning environment that empowers students with the knowledge and competencies needed to tackle the complex challenges of today's world. We believe that education goes beyond the mere transmission of information; it cultivates critical thinking, creativity, and a strong sense of social and environmental responsibility. Through our academic programs and research initiatives, we are dedicated to enhancing education in agriculture and life sciences, empowering individuals and communities alike. Our objective is to promote quality education as a driving force toward a brighter and more sustainable future, fully aligned with the principles and goals encapsulated in SDG 4.

Key 2023 Research Contributions to SDG 4

MATE continues to demonstrate its strong commitment to SDG 4 through transformative research that advances knowledge, fosters innovation, and strengthens educational systems across disciplines. From digital literacy and entrepreneurship to sustainable aquaculture and tourism education, MATE researchers are redefining how education can drive social progress, environmental awareness, and lifelong learning.

29
Publications

173
Citations

A prime example is the study *"Societal Perceptions of Aquaculture: Combining Scoping Review and Media Analysis"*, which engaged experts from MATE's Institute of Aquaculture and Environmental Safety to explore how knowledge dissemination, transparency, and communication shape public perceptions of sustainable food production (Budhathoki et al., 2024). Complementing this, research on *"Design-Based Learning in*

Higher Education" highlighted how innovative pedagogies can elevate creativity, motivation, and design skills among students. Through hands-on, problem-solving learning strategies, the study showcases effective teaching approaches that nurture critical thinking and innovation: key attributes of quality higher education (Oo et al., 2024). Similarly, the study *"The Effect of Reading Strategy Use on Online Reading Comprehension"*, conducted with Hungarian secondary students, demonstrates the importance of developing digital literacy and adaptive reading strategies in the modern learning environment. Its findings guide educators on integrating online reading tools to strengthen comprehension and language achievement, directly supporting SDG 4.4's focus on skills relevant to the 21st-century workforce (Habók et al., 2024).

At the intersection of education and innovation, the *"Development and State of the Art of Entrepreneurship Education"* provides a comprehensive bibliometric review of 3,787 scholarly articles, mapping global trends and identifying key educational gaps. With researchers from MATE's Doctoral School of Economic and Regional Sciences leading the analysis, the study highlights the growing significance of entrepreneurship education in developing employability, creativity, and inclusive economic growth (Talukder et al., 2024a). Similarly, *"Interplay of Influencing Factors Shaping Entrepreneurial Intention: Evidence from Bangladesh"* delves into how educational support, personal attitudes, and perceived behavioural control shape students' entrepreneurial aspirations, reinforcing the transformative role of higher education in equipping youth for self-employment and innovation (Talukder et al., 2024b).

MATE's contribution to sustainability-oriented education extends into environmental sciences and tourism. The *"Structural Model of Formation of Geoecological Competence of Tourism Students"* offers a pedagogical framework for developing environmental awareness and responsibility among future tourism professionals. By embedding geoecological competencies into higher education curricula, the study advances SDG 4.7, ensuring learners are prepared to address ecological and social challenges through their professional practices (Zhoya et al., 2024). In a related study, *"New Frontiers in Tourism and Hospitality Research"* provides an overview of evolving educational and research priorities within the field, advocating for multidisciplinary and technology-driven approaches that align with sustainability, cultural exchange, and responsible tourism (El Archi and Benbba, 2024).

Moreover, MATE's researchers have explored how education interacts with sustainability and behaviour. The paper *"The Behaviour of Students in Relation to Green Marketing as Green Consumers"* reveals how university education fosters environmental awareness and pro-sustainability behaviour among students. This work highlights the value of integrating environmental literacy into curricula, cultivating informed consumers and future leaders who can drive the transition toward sustainable economies (Babu et al., 2024).

The university's commitment to inclusive education also extends to global perspectives. The *"Overview of Ethiopian Public Higher Education"* offers an analytical view of higher education reform, quality assurance, and capacity building in developing contexts. It provides valuable recommendations for improving educational systems through leadership development, equitable access, and quality enhancement, reinforcing SDG 4's emphasis on inclusive and equitable education (Tareke et al., 2024).

Through its multidisciplinary approach, spanning environmental sciences, entrepreneurship, tourism, literacy, and digital learning, MATE equips learners, educators, and professionals with the skills and knowledge necessary

for a sustainable future. Each project reinforces the university's mission to ensure that education not only informs but transforms, empowering individuals to create lasting societal and environmental impact in alignment with SDG 4.

Empowering Europe's Future Learners: E³UDRES² 2.0 at MATE University

Following the success of the original E³UDRES² initiative, the programme has been renewed, marking a new phase in transforming higher education across Europe. Led in Hungary by MATE, this ambitious project continues to unite 10 universities and 36 partners to shape an engaged and entrepreneurial European University.

E³UDRES² 2.0 reimagines education through innovation, interdisciplinarity, and inclusivity, creating a dynamic "Multi-i-Campus" that connects students, educators, and researchers through shared courses, micro-credentials, doctoral schools, and startup incubators. By empowering "ent-re-novators", educators, entrepreneurs, and researchers, to tackle regional and global challenges, the project redefines learning for the future.

Through flexible, mission-driven education and human-centred innovation, E³UDRES² 2.0 strengthens SDG 4: Quality Education, fostering smart learners, sustainable regions, and a resilient European knowledge ecosystem.

Prof. Dr. Ágoston Temesi

The topic of Entrepreneurship Education (EE) has recently become a particularly important area of research, as in developing countries it represents an opportunity for economic growth through encouraging the creation of small and medium-sized enterprises. Accordingly, this research topic is significant not only for scholars in the Western world but is expanding globally as well, which further justifies the examination of the field using bibliometric methods. Our results have identified several research areas that warrant further, more in-depth investigation. These include: improving EE methods in secondary school curricula; EE in adult education and the practical implications of findings for andragogy; EE in least developed countries and its unique challenges; combining EE with internet-based, innovative training and educational approaches such as gamification and simulations; the role and methodological development of EE in societal economic integration; and the specific EE needs of women.

In recent years, we have been conducting primary research in the field of EE, and particularly in Sustainable Entrepreneurship Education, by modeling the behavior of Far Eastern university students.

Dr. Katalin Szili

In collaboration with the Digital Learning Technologies Research Group at the University of Szeged, researchers explored how computer-assisted instruction can help first-grade children develop pre-reading skills and overcome early learning gaps. The playful use of targeted digital tools proved especially effective for disadvantaged learners, enhancing attention, perception, and motivation. By strengthening foundational literacy, the program promotes inclusive and equitable education and contributes to lifelong learning. This initiative supports UN Sustainable Development Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

SDG 5

Gender Equality

Gender equality is a core principle at the Hungarian University of Agriculture and Life Sciences, guiding our values and practices. We strive to create an inclusive environment where everyone has equal opportunities and is treated with respect. This commitment reflects our belief that gender equality is vital for social and economic progress. Our educational programs, research initiatives, and policies focus on empowering women and eliminating gender-based discrimination. Through education and collaboration, we aim to ensure that all individuals can reach their full potential and contribute to a sustainable and equitable society, in line with the goals of SDG 5.

Key 2024 Research Contributions to SDG 5

In 2024, MATE advanced Sustainable Development Goal 5 through diverse and evidence-based research addressing gender equality, women's empowerment, and equitable access to opportunities. Across multiple institutes, MATE's studies examined gender disparities, social inclusion, and systemic reforms aimed at improving the well-being and participation of women in economic, educational, and health sectors.

At the Institute of Rural Development and Sustainable Economy, researchers examined gender representation and empowerment through multiple lenses. A bibliometric study on *Women's Empowerment Post-SDG Adoption* revealed a global rise in gender-focused research since 2015, emphasizing autonomy, education, and employment as drivers of equality (Adeleye et al., 2024). Similarly, the study *Gender Perspectives in Tourism Studies in the MENA Region* highlighted tourism's potential to empower women while exposing the limited gender-sensitive research in the region, calling for stronger academic and policy engagement (Kabil et al., 2024).

9
Publications

97
Citations

Further extending this focus on social equity, the same institute analysed *Hospital Integration and Decubitus Patient Care* as well as CT Diagnostic Access in Hungary. These studies showed

how systemic health reforms, through integrated hospital management and equitable access to smart medical technologies, can reduce disparities in healthcare outcomes. Such improvements directly support SDG 5 by promoting equal access to quality care and reducing gender-based inequities in health services (Szivós et al., 2024).

From an economic and technological standpoint, research on *Fintech Adoption for Women in the Post-COVID-19 Era* explored how digital financial literacy, government support, and technology acceptance influence women's participation in financial systems in Indonesia. The study highlighted the importance of tailored strategies for urban and rural women to close the gender gap in digital finance, contributing to women's economic empowerment through inclusive innovation (Igamo et al., 2024). Similarly, the *Relationships between Sustainable Operations and the Resilience of SMEs* study by the Institute of Agricultural and Food Economics emphasized how sustainable investment practices and effective communication strategies strengthen the resilience of small and medium-sized enterprises, an area where female entrepreneurs play a growing role in promoting local sustainability (Pércsi and Fülöp, 2024).

In another study, MATE researchers also addressed persistent gender imbalances in academia through a bibliometric study on *Gender Differences in Research Fields of Bioeconomy and Rural Development* across Latin America and Africa. The findings revealed that women remain underrepresented in scientific authorship and leadership positions, accounting for only 23% of researchers in these regions. By identifying these disparities, the study calls for institutional measures that promote equitable participation and visibility of women in science and rural innovation (Olivo et al., 2024).

All these research efforts demonstrate our strategic engagement with SDG 5 through multidimensional approaches, ranging from gender-focused bibliometric analyses and inclusive tourism to women's digital and entrepreneurial empowerment, and equitable access to healthcare and education. By generating actionable insights and supporting policy development, MATE continues to contribute to a more inclusive, equitable, and sustainable society where women and men alike can thrive.

Dr. Kinga Nagyné Pércsi

The study"Relationships between Sustainable Operations and the Resilience of SMEs" (Nagyné Pércsi & Fülöp, 2024) explores how sustainability-oriented management practices contribute to the adaptability and long-term performance of Hungarian SMEs. Among the social dimensions of sustainability, the research emphasizes gender equality and inclusive leadership as key elements of resilient organizational culture. The findings underline that companies promoting equal opportunities and female participation in decision-making are more capable of coping with crises and fostering innovation. This contribution aligns with SDG 5 by highlighting the importance of gender-inclusive business strategies in advancing sustainable and socially responsible entrepreneurship.

SDG 6

Clean Water and Sanitation

The Hungarian University of Agriculture and Life Sciences prioritizes Sustainable Development Goal 6, which centres on "Clean Water and Sanitation." Clean water is vital for life, agriculture, and the environment. We emphasize research, education, and innovation in water management, environmental science, and agriculture to foster sustainable practices that safeguard water resources for future generations.

Through our academic programs, research initiatives, and community outreach, we address clean water and sanitation challenges in Hungary and beyond. We understand that access to safe and clean water is essential for health and well-being. Our commitment to achieving SDG 6 underscores our mission to promote a more sustainable and equitable world.

Key 2024 Research Contributions to SDG 6

In 2024, researchers at the MATE deepened their commitment to SDG 6: Clean Water and Sanitation, through a range of studies that reimagined how water can be used, managed, and protected in both natural and human systems. From exploring the chemistry of rivers and lakes to optimizing irrigation and modernizing aquaculture, MATE's scientists demonstrated how innovation and environmental stewardship can go hand in hand in ensuring a sustainable water future.

36
Publications

337
Citations

Protecting and improving water quality (SDG 6.3) stood at the heart of several major research efforts. In the Danube Basin, a team from the Institute of Environmental Sciences applied geochemical modelling, multivariate analysis, and Monte Carlo simulations to assess surface water quality for irrigation, drinking, and ecological safety, revealing how geological processes and human pressures shape water composition (Saeed et al., 2024). Complementing this, the Department of Plant Protection

explored how heavy metals such as mercury and cadmium move through aquatic food webs, highlighting the ecological and health risks of bioaccumulation. Meanwhile, the Institute of Aquaculture and Environmental Safety detected widespread microplastic pollution in Lake Balaton and the Kis-Balaton Wetland, tracing the sources to wastewater, road runoff, and tourism. Together, these studies underscore that clean water depends on both prevention and consistent monitoring.

Ensuring safe water and sanitation (SDG 6.1 and 6.2) was another key focus. The Institute of Food Science and Technology investigated biofilm formation in drinking water networks, revealing that plastic-based systems such as PVC and HDPE are more effective at preventing bacterial buildup than traditional metal pipes. However, the growing presence of chlorine-resistant bacteria highlights the urgent need for innovation in water treatment and infrastructure management.

At the same time, MATE's agricultural research advanced new ways of using water more efficiently (SDG 6.4). The Institute of Plant Production conducted a long-term analysis of drip irrigation in asparagus plantations, showing increasing water demands under changing climatic conditions. Similarly, Kocsis et al. demonstrated that adjusting irrigation and fertilizer levels in sweet corn cultivation can maximize yield while minimizing water use. Beyond Europe, research on soil and water conservation practices in Kenya revealed that education, farm size, and land tenure strongly influence sustainable farming adoption, linking water management to livelihoods and equity.

MATE's work also pushed forward integrated water resources management (SDG 6.5) by applying advanced data and modelling tools to better understand how land, climate, and water systems interact. Using satellite imagery and GIS, the Institute of Landscape Architecture, Urban Planning and Garden Art analysed water–land dynamics in China's Lake Dianchi Basin, one of Asia's most challenging lake environments. Their research exposed the lasting effects of urban expansion on water pollution and stressed the need for multi-dimensional governance that links land-use planning, water policy, and environmental restoration. Similarly, machine learning approaches were used to monitor inland water inundations, offering early-warning systems that improve water resilience under climate uncertainty. Finally, in protecting aquatic ecosystems (SDG 6.6), MATE optimized carp aquaculture systems to balance productivity with water quality and developed an energy-efficient aquaponics model that cut energy use by over 15%, advancing circular, resource-smart food systems.

Together, these studies reflect MATE's dynamic approach: uniting innovation, sustainability, and stewardship to ensure that every drop of water count, for people and for the planet.

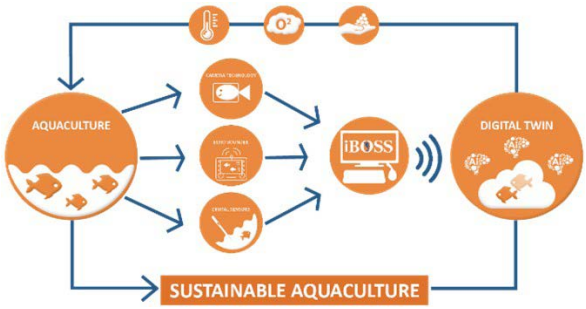
Smart Farming of African Catfish: MATE's Innovation for a Water-Wise Future

Feeding the world sustainably starts with smarter water use — and MATE researchers are leading the charge. Within the EU-funded iFishIENCi project, which brings together 16 international partners, the Institute of Aquaculture and Environmental Safety has developed the innovative "Smart Farming of African Catfish" system, a data-driven leap toward cleaner, more efficient aquaculture.

Recognized by the European Commission's Innovation Radar as a "marketable innovation with strong market creation potential," this breakthrough blends AI and IoT technologies to track fish health, feeding behaviour, and

water quality in real time. The result: healthier fish, smarter feeding, and minimal water waste.

By turning sludge and wastewater into valuable resources, the system achieves a zero-waste approach, proving that aquaculture can be both productive and planet-friendly. With innovation flowing from science to sustainability, MATE is helping shape a water-wise future for global food production.



Jelena Stanivuk

Intensive aquaculture faces the critical challenge of maximizing fish production per unit of water as freshwater resources become increasingly scarce due to climate change. This research employed a fractional factorial experimental design to systematically analyse, strength of factors and their interactions. Further to rank four intensification factors (feeding rate, stocking density, aeration, and polyculture) in common carp pond production, testing the limits of intensification up to 11 tonnes per hectare. The study revealed that feeding management is the most influential factor in optimizing water use efficiency, followed by stocking density, while aeration and polyculture showed less impact under the tested conditions. These findings provide evidence-based guidelines for aquaculture practitioners to achieve higher productivity per unit of water through smart management practices, directly supporting SDG 6's goal of ensuring sustainable water use and contributing to MATE's research profile in climate-adapted, resource-efficient food production systems.

Dr. Judit Háhn

At the Hungarian University of Agriculture and Life Sciences (MATE), research on microplastic contamination contributes directly to SDG 6 (Clean Water and Sanitation) by advancing sustainable freshwater management. The 2024 study *"Spatial Variations in Microplastics in the Largest Shallow Lake of Central Europe and Its Protecting Wetland Area"* presents the first comprehensive assessment of microplastic pollution across two uniqe aquatic ecosystems (Lake Balaton and the Kis-Balaton Water Protection System and its catchment area). The research identified spatial variability in contamination levels and polymer composition, with polyethylene and polypropylene fragments predominating and local peaks linked to wastewater effluent, road runoff, and tourism. By revealing that wetlands can both filter and retain microplastics, the study provides critical baseline data for effective water-quality protection and pollution-source control. These findings strengthen MATE's scientific profile in environmental sustainability and reinforce its commitment to evidence-based solutions for protecting aquatic ecosystems. The research also reflects MATE's broader strategic focus on water-related environmental sciences, ecosystem management, and circular economy principles, showcasing the university's interdisciplinary approach to addressing complex sustainability challenges.

Dr. Andrea Taczmanné Brückner

Microorganisms present in drinking water and forming biofilms on the surfaces of drinking water distribution systems and storage tools can pose health risks and adversely affect the sensory quality of water. One area of our research is to understand the properties of bacteria found in drinking water networks (antibiotic resistance, chlorine resistance) and, with this new knowledge, to develop strategies to combat biofilm formation. Our investigations also cover the removal of biofilm that forms on the inner walls of drinking bottles, which are becoming increasingly common in everyday life. Our research has shown that biofilm formation is influenced by, among other things, the material of the bottle, the nature of the medium stored in the bottle, and the microbiota that forms the biofilm. Careful selection of the material used for refillable bottles and proper cleaning of the bottles can reduce the regular purchase of water and flavored teas available in PET bottles and the accumulation of PET bottles as waste.

SDG 7

Affordable and Clean Energy

The Hungarian University of Agriculture and Life Sciences is dedicated to the principles of Sustainable Development Goal 7, "Affordable and Clean Energy." We understand that access to clean and affordable energy sources is essential for sustainable development, agricultural practices, and environmental protection. Our institution focuses on researching and promoting energy-efficient technologies, renewable energy sources, and sustainable agricultural practices. We engage in education, innovation, and the sharing of knowledge to tackle challenges related to energy access, security, and sustainability. By advancing research and education in agriculture, environmental science, and renewable energy, we aim to contribute to a future where clean and affordable energy is accessible to all, fostering both economic growth and environmental stewardship. We view SDG 7 as a foundational element for achieving a more sustainable and prosperous world and are committed to playing an active role in realizing this goal.

Key 2024 Research Contributions to SDG 7

In 2024, our researchers made significant strides in advancing sustainable energy research, tackling the global challenge of transitioning toward cleaner, more efficient, and accessible energy systems. Their collective efforts spanned the development of renewable technologies, biofuel innovation, and the optimization of solar energy systems, contributing directly to the achievement of SDG 7: Affordable and Clean Energy.

52
Publications

403
Citations

At the Institute of Technology, pioneering research explored the potential of biomass and biofuels as key drivers of the global energy transition. The study *"Biomass Energy and Biofuels: Perspective, Potentials, and Challenges in the Energy Transition"* highlighted how bioenergy can transform waste into valuable resources, reducing dependence on fossil fuels while supporting a circular economy (Mignogna et al., 2024). Complementing this, research on sustainable aviation fuels (SAFs) revealed how renewable bio jet fuels, microalgae-based aviation biofuels, and advanced catalysts could help decarbonize

the aviation industry, aligning SAF innovation with several SDGs, including affordable energy and climate action (Raman et al., 2024).

Renewable energy efficiency also took centre stage in 2024. Several experimental and numerical investigations conducted in Gödöllő demonstrated how nanofluids, particularly silicon carbide and graphene-based hybrids, can dramatically improve heat transfer in solar collectors, boosting their thermal and exergy efficiencies by more than 35%. Further studies enhanced parabolic trough and solar air collector designs, showing how optimized fin geometry and entrance flue configurations can improve heat exchange and energy recovery, making solar systems more efficient and viable for diverse climates. Similarly, research on solar organic Rankine cycles (ORC), both in Hungary and under tropical conditions, revealed pathways for small-scale electricity generation using solar heat and phase change materials, promoting renewable energy use in rural and remote areas (Ismail Permana et al., 2024).

The Department of Building Engineering and Energetics contributed to sustainability in the built environment through an in-depth review of semi-transparent building-integrated photovoltaics (BIPV). Their findings showed that while these systems may reduce indoor illuminance, they improve daylight quality and visual comfort, offering a balanced approach between energy efficiency and occupant well-being (Khele and Szabó, 2024). Meanwhile, the Centre for Circular Economy Analysis and Knowledge analysed global green building energy patents, revealing emerging trends in hydrogen technology, intelligent building systems, and energy storage, underscoring the growing role of innovation and data-driven design in shaping sustainable urban infrastructure (Alharasees et al., 2024).

MATE researchers also introduced creative approaches to urban solar integration, such as the "Sunflower Solar Tree," which produced up to 23% more energy than traditional flat photovoltaic modules while saving 85% of land area, demonstrating a powerful synthesis of efficiency, aesthetics, and land-use optimization (Almadhhachi et al., 2024). Moreover, studies on the impact of climate change on photovoltaic systems forecasted how rising temperatures could affect solar efficiency, providing insights into active cooling strategies and future system designs.

Together, these studies underscore MATE's holistic commitment to advancing sustainable energy research, from next-generation biofuels and nanotechnology-enhanced solar systems to intelligent building solutions and energy policy innovation. By bridging science, technology, and environmental responsibility, MATE continues to play a vital role in shaping a cleaner and more energy-secure future, both in Hungary and globally.

WaterGreenTreat: From Wastewater to Water Wisdom

WATER GREEN TREAT

As the world races toward a sustainable energy future, the WaterGreenTreat project is proving that clean water and clean energy can go hand in hand. Bringing together leading institutions from Hungary, Romania, Spain, and France, including MATE, this forward-thinking initiative is transforming wastewater treatment into an energy-smart, sustainable process.

Using eco-friendly, 3D-printed photocatalysts made from metal oxide composites, researchers are developing a green technology that harnesses solar energy to purify industrial wastewater for agricultural reuse. By integrating microalgae and "phyto-synthesis" techniques, the process not only eliminates pollutants but also recovers valuable resources, supporting energy efficiency and circularity.

At MATE's Institute of Aquaculture and Environmental Safety, scientists ensure that the system's reclaimed water is safe and sustainable. Running from 2024 to 2027 under the Water4All Partnership, WaterGreenTreat embodies SDG 7: Affordable and Clean Energy: advancing solar-driven innovation for a cleaner, greener future.

Prof. Dr. István Farkas

Hungary's continued reliance on fossil fuel-based energy highlights the necessity for advancing research in affordable and clean energy technologies including solar energy which represents a promising alternative to enhance energy security and reduce greenhouse gas emissions.

This study investigates the enhancement of thermal efficiency in double-pass solar air collectors through the integration of V-angled perforated fins aiming at optimising thermal performance by improving heat transfer characteristics and airflow distribution within the collector system.

Experimental results emphasise the pivotal role of fin geometry and airflow management in improving the overall efficiency of solar air collectors, especially the incorporation of V-angled perforated fins which can a notable increase in thermal efficiency, underscoring the potential of this design for sustainable energy applications.

The findings contribute to the ongoing development of cost-effective and environmentally responsible solar thermal systems and future work exploring fin-integrated solar collector configurations and their scalability for wider implementation, supporting the broader objective of achieving affordable, reliable, and sustainable energy for all.

SDG 8

Decent Work and Economic Growth

The Hungarian University of Agriculture and Life Sciences (MATE) is committed to advancing Sustainable Development Goal 8: Decent Work and Economic Growth. We believe that true economic progress begins with meaningful, dignified employment. Through cutting-edge education and research, MATE prepares future professionals with the skills and mindset needed to build resilient careers in agriculture, life sciences, and environmental sustainability.

Our initiatives promote inclusive economic growth, reduce unemployment, and foster sustainable farming and business practices. By shaping policies that create fair job opportunities, safeguard labour rights, and encourage responsible enterprise, we aim to ensure that prosperity is shared by all. Guided by the values of SDG 8, MATE envisions a future where every individual can thrive through decent work, driving both social well-being and sustainable economic development.

Key 2024 Research Contributions to SDG 8

112
Publications

626
Citations

In 2024, MATE reaffirmed its commitment to advancing SDG 8. Across its institutes, MATE researchers explored how innovation, human capital, and sustainability-driven policies can build resilient economies and empower people in an evolving global landscape.

A central contribution came from the Department of Agricultural Management and Leadership Science, where two complementary studies explored Green Human Resource Management (GHRM). A comprehensive review revealed a growing integration of environmental awareness into human resource policies worldwide, positioning GHRM as a key driver of employee engagement and sustainable corporate behaviour. Yet, implementation remains moderate, particularly in linking en-

vironmental performance with social and economic outcomes: signalling opportunities for further development. Complementing this, an empirical study demonstrated that GHRM practices significantly enhance employees' green behaviour through environmental knowledge sharing and self-efficacy, highlighting the power of leadership and workplace culture in achieving sustainability goals (M. Miah et al., 2024).

From the Institute of Agricultural and Food Economics, several studies examined how technology, finance, and entrepreneurship intersect to drive sustainable growth. A systematic review on Industry 4.0 technologies in South Asia identified digital skills, artificial intelligence, and big data analytics as critical for future employability, productivity, and competitiveness: directly supporting SDG 8.2 on innovation-led growth (Md. T. Miah et al., 2024a). Another study on urban agriculture and sustainable finance in Ethiopia showed how financial mechanisms and supportive policies can stimulate local food production and green entrepreneurship, strengthening livelihoods in urban settings. Similarly, research on Shariah-based FinTech peer-to-peer financing explored how digital financial literacy and consumer trust enhance inclusive financial systems and economic participation, aligning with SDG 8 (Setiawan et al., 2024).

In tourism, MATE researchers investigated destination branding and sustainability, emphasizing how digital transformation, inclusivity, and community engagement can balance competitiveness with environmental and cultural responsibility. The study calls for innovative branding that merges authenticity with sustainability: ensuring long-term value for destinations and local economies. Research from the Institute of Environmental Sciences offered a different lens, examining the environmental impacts of conflict-driven internal displacement in Darfur, Sudan. Using satellite-based analysis, the study showed how population shifts influence vegetation and land use, providing crucial data for rebuilding livelihoods and promoting resource-efficient recovery in conflict-affected areas (Ahmed et al., 2024).

Together, these research efforts highlight MATE University's belief that economic growth and sustainability are not opposing goals but shared pathways toward a better future. By empowering people, advancing innovation, and promoting environmental responsibility, MATE is helping shape economies that work for both people and the planet: proving that progress, when guided by purpose, can truly be sustainable.

Empowering Researchers, Elevating Excellence: MATE and the HRS4R Journey

The Hungarian University of Agriculture and Life Sciences (MATE) proudly stands among Europe's leading research institutions with its HR Excellence in Research Award, a distinction granted by the European Commission under the Human Resources Strategy for Researchers (HRS4R) initiative. As the first university in Hungary to achieve this recognition, MATE demonstrates a strong commitment to creating an inspiring, fair, and supportive research environment.

Through the HRS4R framework, MATE promotes transparency, equal opportunities, and international mobility for researchers, empowering both students and staff to grow within a dynamic European research community. Its participation in the EURAXESS network further enhances global collaboration, ensuring researchers have access to valuable opportunities, training, and partnerships.

Prof. Dr. Szilvia Erdeiné Késmárki-Gally

Our study systematically examined how Industry 4.0 technologies, such as artificial intelligence, big data, and automation, affect workforce employability and skills development in South Asia. By identifying the key success factors and barriers to technological adoption, the research provides actionable insights on how digital transformation can foster sustainable economic growth and decent work opportunities in line with SDG 8.

The findings emphasize the importance of targeted investment in digital skills and training to maximize the employment potential of Industry 4.0 technologies. The proposed "Industry 4.0 SEI Framework" offers strategic guidance for policymakers and industry leaders to enhance productivity, inclusion, and workforce resilience.

This approach reflects MATE's mission to connect technological innovation with social well-being and sustainable economic development. Through this work, MATE strengthens its international visibility as a research hub promoting inclusive, future-oriented labour market transformation.

SDG 9

Industry, Innovation and Infrastructure

Sustainable Development Goal 9 – Industry, Innovation and Infrastructure aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation as drivers of long-term economic growth and environmental sustainability. The Hungarian University of Agriculture and Life Sciences (MATE) actively contributes to this goal through cutting-edge research, innovation-driven education, and strong collaboration with industry and policy stakeholders. We actively contribute to innovation and the development of modern infrastructure to meet the evolving needs of our society. The University's activities cover a broad range of areas—from the development of smart agricultural technologies and precision farming solutions to advancements in food processing, renewable bio-based materials, and circular economy models. MATE also plays a key role in strengthening regional innovation ecosystems by supporting technology transfer, and digital transformation in agriculture and the life sciences. Through these initiatives, MATE promotes sustainable industrial development and builds bridges between science, innovation, and society to foster resilient and future-oriented infrastructure.

Research contribution to SDG 9

Sustainable aviation fuel (SAF) represents a crucial innovation in reducing the aviation sector's environmental impact and supporting the global transition toward low-carbon energy systems. Raman et al. (2024) analyse how SAF research aligns with the United Nations Sustainable Development Goals (SDGs), identifying dominant thematic areas and research gaps. Their findings show that most SAF studies focus on climate action (SDG 13), clean energy (SDG 7), and responsible consumption and production (SDG 12), emphasizing emission reduction, energy efficiency, and sustainable production technologies. From the perspective of SDG 9 (Industry, Innovation and Infrastructure), the authors highlight that SAF research fosters innovation through the development of advanced bio-based production routes, catalytic processes, and circular economy approaches. However, industrial scalability, infrastructure integration, and technology transfer remain underrepresented

66
Publications

419
Citations

areas. Strengthening these aspects could significantly enhance the contribution of SAF research to sustainable industrial development and innovation.

The COVID-19 pandemic posed severe challenges to global supply chains, disrupting production, logistics, and distribution networks while exposing the vulnerability of traditional systems. In response, organizations increasingly turned to digital transformation and collaborative strategies to maintain resilience and sustainability. Javed et al. (2024) examined how advanced technologies—such as artificial intelligence, blockchain, the Internet of Things, and big-data analytics—along with strong supply chain collaboration, influence sustainable supply chain performance during crises. Their findings show that while the pandemic had a direct negative effect on supply chain sustainability, the adoption of advanced technologies and improved collaboration among partners significantly mitigated these impacts. Moreover, government support and enabling policies further strengthened the positive effects of technology use on sustainable outcomes. The study emphasizes that digital innovation and cross-sector collaboration are essential drivers of resilient and sustainable industrial systems.

Organizations are increasingly recognizing the importance of environmentally sustainable practices, with human resource management playing a pivotal role in promoting green initiatives. Miah et al. (2024) conducted a systematic literature review on Green Human Resource Management (GHRM), analyzing research trends, antecedents, and implementation levels in relation to organizational sustainability. The study finds that GHRM encompasses diverse areas such as environmental management and sustainability, with a strong focus on employees' sustainable behaviour and environmental performance, while social sustainability and economic outcomes remain less explored. Quantitative studies dominate the field, mostly conducted in developing countries, and the practical implementation of GHRM in organizations is generally moderate. GHRM contributes to sustainable industrial development by fostering innovation, strengthening organizational processes, and integrating green practices into management systems.

Dragon fruit waste, including peels, seeds, and stems, represents an underutilized resource with potential for producing bioactive compounds and sustainable formulations. Tripathi et al. (2024) review eco-friendly and cost-effective valorisation strategies, highlighting microbial conversion, green extraction methods, and biorefinery processes to transform dragon fruit by-products into bioethanol, pharmaceuticals, and other value-added products. The study emphasizes the importance of pre-treatment and extraction techniques for maximizing recovery of valuable biomolecules and examines their applications across food, pharmaceutical, and biofuel industries. The research demonstrates how innovative bioprocessing and industrial valorisation of agricultural waste can contribute to sustainable industrial development, technological advancement, and the creation of resilient and resource-efficient production systems.

VAX4ASF – New technologies for African swine fever vaccines

VAX4ASF is a Horizon Europe-funded international research initiative aimed at developing a next-generation vaccine against African Swine Fever (ASF), a highly contagious and deadly disease affecting pigs and wild boars. Led by the Spanish biopharmaceutical company HIPRA, the project brings together 17 partners from Europe, Kenya, and the United States, including the Hungarian University of Agriculture and Life Sciences (MATE). The consortium focuses on innovative vaccine technologies and advanced modelling to understand ASF transmission

dynamics, especially at the wildlife-domestic interface. By providing effective tools for disease control, VAX4ASF contributes to global animal health, sustainable agriculture, and biodiversity protection.

Dr. Virág Walter

In the 21st century, organizations are increasingly focusing on sustainability, environmental protection and other issues related to green policies. These appear in many areas, such as employees' sustainable behaviour, but also in social sustainability and economic performance. Over the past three decades, organizations have been responsible for maintaining a balance in the triangle of economic, environmental and social sustainability. In recent years, research on green human resource management has also been linked to corporate sustainability goals, such as in the case of MATE, which has been taking action since its establishment. Our research group has carried out publications on the growing importance of green human resource management (GHRM) for organizational sustainability, the effects of GHRM practices on employees' green behaviour: the role of employees' environmental knowledge management and green self-efficacy in greening the workplace, a multigroup analysis focusing on green behaviour of university employees in greening the workplace, and consumer awareness and motivational factors in second-hand clothing purchases.

SDG 10

Reduced Inequality

SDG 10 – Reduced Inequalities focuses on reducing income, social, and opportunity disparities both within and among countries, fostering inclusive growth and equitable access to resources, services, and decision-making processes. The Hungarian University of Agriculture and Life Sciences (MATE) contributes to this goal through a wide range of research and educational activities that address social, economic, and regional inequalities, particularly in rural and agricultural contexts. The University's research encompasses topics such as inclusive agricultural practices, equitable access to technology and knowledge, sustainable rural development, and socio-economic policies aimed at marginalized communities. In addition, MATE actively engages in capacity-building, outreach programs, and multi-stakeholder collaborations, ensuring that its scientific findings are translated into practical strategies that promote fairness, social inclusion, and empowerment. Through these efforts, the University supports the creation of more equitable systems and contributes to reducing disparities, directly advancing the objectives of SDG 10.

Research contribution to SDG 10

Tourism is increasingly recognized as a powerful tool for enhancing gender equality and women's empowerment. Kabil et al. (2024) conducted a bibliometric analysis of gender-focused tourism research in the MENA (Middle East and North Africa) region. Their findings indicate that while interest in gender perspectives within tourism is growing, overall scientific production remains limited and unevenly distributed across countries, with Egypt, Jordan, Israel, and Oman showing greater engagement. The study underscores the importance of integrating gender considerations into tourism research to promote social inclusion and equity. By highlighting gaps, the authors call for more inclusive scholarly inquiry that can inform policies and practices aimed at reducing gender disparities and empowering women within the tourism sector, contributing to broader efforts to diminish inequalities within and among countries.

22
Publications

114
Citations

In the post-COVID-19 era, the adoption of financial technology (FinTech) among women has become a pivotal factor in promoting financial inclusion and reducing gender disparities. Igamo et al. (2024) conducted a study examining the determinants influencing FinTech adoption among women, extending the Technology Acceptance Model (TAM) to include factors such as attitude, digital financial literacy, government support, and the value of status quo. The research revealed that while government support and digital financial literacy have a moderate impact on adoption, the value of status quo plays a significant role in mediating the relationship between behavioural intention and actual usage behaviour, with notable differences observed between urban and rural women. These findings underscore the importance of addressing socio-cultural and infrastructural barriers to enhance women's participation in the digital financial ecosystem. This study highlights the critical need for targeted interventions that promote digital financial literacy, provide government support, and challenge existing norms to empower women economically and bridge the gender digital divide.

In an increasingly interconnected financial landscape, understanding how banks' structural decisions influence performance is essential for promoting equitable economic growth. In their study, Muhammed et al. (2024) examined how capital structure affects the financial performance of Ethiopian commercial banks, drawing on six years of audited data from 14 institutions. Their analysis reveals that the loan-to-deposit and total deposit-to-asset ratios have a significant positive effect on return on assets, while rapid asset growth shows a negative relationship. These findings suggest that efficient capital management enhances financial stability and resilience in the banking sector, underscoring the importance of sound financial structures in fostering inclusive growth and reducing disparities by improving access to stable and sustainable financial services.

AGRIGEP – Gender Equality Plans in Agriculture and Life Sciences

The project entitled "Assessment and Implementation of Agriculture and Life Science Universities' First Gender Equality Plans in Widening Countries" is a Horizon Europe initiative coordinated by MATE. Launched in 2023, AGRIGEP aims to address gender inequality in research and education institutions, particularly within agriculture and life sciences. The project supports partner universities in developing and implementing their first Gender Equality Plans (GEPs), tailored to sector-specific challenges. It focuses on capacity building, structural reforms, and the creation of inclusive strategies to promote gender balance in STEM fields, especially in institutions from widening countries. AGRIGEP also emphasizes the importance of empowering students and staff from diverse backgrounds, including those from developing countries.

Dr. Tibor Farkas

A Bibliometric Analysis of Women's Empowerment Studies Post Sustainable Development Goal Adoption Periods (2015–2022)" directly relates to SDG 5 by examining the academic focus on women's empowerment, a core aspect of achieving gender equality. It highlights how research trends have evolved since the adoption of the SDGs, reflecting global efforts to promote women's rights and participation. Additionally, the study connects to SDG 10 by addressing disparities in representation and access, particularly in marginalized communities. By analysing geographic and thematic patterns, the article sheds light on persistent inequalities and the scholarly response to reducing them.

SDG 11

Sustainable Cities and Communities

SDG 11 - Sustainable Cities and Communities focuses on making cities and human settlements inclusive, safe, resilient, and sustainable. As urbanization accelerates worldwide, ensuring sustainable development in cities has become one of the most pressing global challenges. The Hungarian University of Agriculture and Life Sciences (MATE) contributes to this goal through interdisciplinary research and innovation addressing urban resilience, green infrastructure, waste management, sustainable mobility, and community development. MATE's academic and applied research supports the transition toward smart and sustainable urban environments by integrating environmental protection with social inclusion and economic efficiency. Through projects focusing on sustainable rural–urban linkages, ecosystem services, renewable energy use, and sustainable food systems, the university actively promotes the principles of circular economy and ecological urban design. By engaging local communities, fostering environmental awareness, and providing evidence-based policy recommendations to addressing the urban-rural nexus, MATE's research directly contributes to the realization of SDG 11, helping to build liveable, equitable, and future-oriented settlements both in Hungary and internationally.

Research contribution to SDG 11

56
Publications

156
Citations

Urbanization is exerting mounting pressure on waste management systems worldwide, particularly in fast-growing developing countries like Indonesia. Wikurendra et al. (2024) provide a comprehensive review of how rapid population shifts to urban areas have led to a steep increase in municipal solid waste, highlighting that inefficient disposal practices are contributing to significant environmental degradation and public-health hazards. By exploring the status of waste-generation trends, traditional management shortcomings, and the potential of integrating a circular-economy framework, the authors identify five key economic sectors where adoption of circular practices—such as reuse, recycling, refurbishing and remanufacturing—could yield substantial benefits. This work details how embedding circular-

economy models within urban waste infrastructure can enhance service coverage, reduce environmental burdens in urban settlements and support more resilient, inclusive and sustainable city systems.

Urban agriculture is increasingly recognised as a promising strategy to enhance food security, build resilient cities, and support sustainable urban systems. Desalegn et al. (2024) examined how government policies and regulations influence the promotion of urban agriculture in Ethiopia, using sustainable finance as a mediating factor. They employ a mixed-methods, explanatory design with data from micro and small enterprises, applying structural equation modelling. Their findings indicate that while policies and regulations alone do not exert a significant direct effect on urban agriculture, sustainable finance plays a crucial mediating role, meaning that government regulation impacts urban agriculture indirectly through access to inclusive, environmentally and socially oriented funding. The study highlights the importance of combining supportive policy frameworks with sustainable financial mechanisms to integrate urban agriculture into the fabric of urban planning.

Urban expansion and the conversion of green and seminatural spaces into built-up areas present major challenges for the development of sustainable human settlements. In their study, Filepné Kovács et al. (2024) analyse peri-urban zones in Central and Eastern Europe to assess how policy instruments influence urban sprawl deceleration and the preservation of green infrastructure. By combining questionnaire data on spatial-planning, regulatory and economic tools with spatio-temporal land-cover analysis (1990–2018), the authors find that although urban sprawl was intense after 1990, the pace generally slowed after 2000, and approximately one-third of the studied areas remained stable natural or seminatural zones. The research highlights that traditional nature-conservation legal tools can be effective in safeguarding green areas, but that many peri-urban regions still lack specific instruments to control the spread of artificial surfaces, especially where spatial-planning competences are fragmented. The study emphasizes the importance of coherent policy frameworks and land-use governance to ensure that urban growth respects ecological values.

RURALITIES - Climate-Smart Rural Innovation Centres

The project titled “Climate-smart, ecosystem-enhancing and knowledge-based rural expertise and training centres” brings together a vast international consortium spanning academia, research institutes, and community development organizations across more than 20 countries. The initiative aims to establish a network of rural training hubs built around living labs and a blockchain-enabled digital platform to empower over 1,000 trained facilitators including trainers, hub coordinators and role models. The project implements and validate its methodology in seven “Simplified Rural Socio-Ecological Systems” across Europe (Italy, UK, Slovenia, Spain, Romania) to support regional authorities in regions where rural innovation networks are lacking, helping to shape policy instruments, foster sustainable rural development, and drive innovation across multi-actor, multi-discipline, multi-scale contexts.

Dr. Krisztina Filepné Kovács

The paper (Policy instruments as a trigger for urban sprawl deceleration: monitoring the stability and transformations of green areas) contributes to Sustainable Development Goal 11 (Sustainable Cities and Communities) by examining how policy instruments can help manage urban growth and urvab sprawl and protect green areas in Central and Eastern Europe. It highlights that, following the socialist era, rapid suburbanisation led to dispersed urban structures and the loss of agricultural land. Through spatial and policy analysis, the study found that traditional nature conservation

tools effectively preserved natural and semi-natural areas, even amid urban expansion. However, it also revealed that fragmented spatial planning responsibilities weaken control over urban sprawl. Overall, the research supports SDG 11 by providing evidence-based insights and monitoring methods to promote more sustainable, well-planned, urban development with the cautious use and protection of natural/ semi-natural areas.

Dr. Anikó Khademi-Vidra

One of our university's key publications focuses on innovative processes in sustainable cities and communities. The research examines the development of urban mobility, with particular emphasis on environmentally conscious and efficient public transportation. The findings contribute to fostering more balanced and cooperation-based relationships between urban and rural areas. The analysis of public transport users' satisfaction supports the improvement of transport systems, primarily by reducing environmental impacts and enhancing quality of life. This research directly aligns with our university's commitment to Sustainable Development Goal 11, which aims to create inclusive, responsible, and livable urban communities (Khademi, Nemecz and Bakos 2024).

Prof. Dr. László Kollányi

Uncontrolled development of waterfront areas can have a critical impact on lake water quality and lead to the degradation and destruction of lake ecosystems. Among the SDG targets, water quality protection (SDG6) and sustainable urban environments (SDG11) are both given priority attention. Our joint article, "Analyzing and forecasting water-land dynamics for sustainable urban developments: A multi-source case study of Lake Dianchi's environmental challenges (China)", published in the journal Ecological Indicators, presents the interaction between these two important SDG areas. Dianchi plateau lake ecosystem in China has been damaged by extensive human construction projects, leading to water pollution. The development serves as a prominent example of urbanization and human interference, drawing global scholarly interest. Restoring Lake Dianchi's water quality remains a global challenge despite 40 years of treatment, with unclear links to surrounding land development.

Research based on Geographic Information Systems (GIS) and satellite imagery has shown that there is a close correlation between the development of waterfront areas and the deterioration of water quality. However, the research also found that the development of areas further away from the lake shore also causes water quality to deteriorate, albeit to a lesser extent.

Prof. Dr. Viktória Szente

One of the authors of the study, "Behavioral Intention in Domestic Heritage Tourism—An Extension of the Theory of Planned Behavior", Dr. Viktória Szente said: "Our results (Osiako & Szente, 2024) suggest that the extended TPB model is more efficacious across all five tested constructs —attitude, subjective norm, perceived behavioural control, motivation, and perceived safety and security — positively influencing the intention to visit heritage sites among domestic tourists.

SDG 12

Responsible Consumption and Production

SDG 12 - Responsible Consumption and Production aims to ensure sustainable patterns of production and consumption by promoting resource efficiency, waste reduction, and circular economy practices. The academic programs of the Hungarian University of Agriculture and Life Sciences (MATE). are dedicated to equipping our students and stakeholders with the knowledge and competencies necessary to foster more sustainable and efficient patterns of consumption and production, including conscious production systems, sustainable packaging, and waste valorisation technologies that minimize environmental footprints. The university's interdisciplinary projects also focus on life cycle assessment, renewable resource utilization, and the transformation of agricultural by-products into high-value materials. By proactively fostering collaboration between academia, industry, and policymakers, MATE plays a key role in accelerating the transition toward circular and sustainable production models in agriculture and food processing. Through its commitment to knowledge transfer, responsible innovation, and sustainability education, MATE contributes significantly to achieving SDG 12 and to shaping more responsible and resilient production and consumption systems in Hungary and beyond.

Research contribution to SDG 12

91
Publications

606
Citations

In 2024, MATE produced 91 publications and received 606 citations related to SDG 12 (Responsible Consumption and Production), according to Scopus-indexed data. These figures reflect the university's strong research activity in promoting sustainable production systems, circular economy solutions, and waste valorisation practices. The steady citation impact highlights the scientific relevance and international visibility of MATE's work in developing innovative methods for resource efficiency, and environmentally responsible consumption patterns.

Global energy demand and environmental sustainability have driven increased interest in alternative energy sources, with biomass and biofuels emerging as key components of the

transition from fossil fuels. Mignogna et al. (2024) examined the potential, challenges, and perspectives of biomass energy, highlighting its role in reducing greenhouse gas emissions while balancing the competition between food and fuel feedstocks. The authors discuss renewable biofuel production processes, technological innovations, and agricultural considerations necessary for sustainable implementation. Their findings demonstrate that integrating biomass and biofuel solutions into energy systems can support responsible industrial practices, optimize resource use, and reduce the ecological footprint of energy production. This underscores the importance of aligning energy innovation with sustainable agricultural and industrial policies to ensure that the transition to renewable fuels advances both environmental and socio-economic sustainability goals.

In their study, Zahid et al (2024) examined how firms' environmental, social, and governance (ESG) performance influences capital structure decisions in Chinese A-listed companies, drawing on 6 295 firm-year observations from 2010 to 2019. The authors reveal that higher ESG performance is linked to reduced reliance on debt and increased access to equity financing, indicating that firms with stronger sustainability credentials enjoy greater investor confidence and financial flexibility. Although audit quality—measured through the involvement of Big Four auditors—does not significantly moderate this relationship, ESG performance itself emerges as a key determinant of sustainable financing behaviour. The research highlights how integrating ESG considerations into corporate strategy can foster responsible financial and production practices, promoting transparency, efficient resource allocation, and long-term sustainability within the business sector.

Sustainable industrial performance increasingly depends on the integration of advanced technologies and environmentally conscious management practices. In 2024, Masud et al. investigated how organizational STARA (Smart Technology, Artificial Intelligence, Robotics, and Algorithms) capabilities influence green human resource management (GHRM) and green supply chain management (GSCM) practices, and how these in turn affect sustainable performance in Bangladesh's manufacturing sector. Using survey data, the authors find that STARA capabilities positively enhance GHRM and GSCM, which mediate the impact of technology on sustainability outcomes. The study demonstrates that leveraging technological innovation together with green management practices can optimize resource use, reduce environmental impacts, and foster responsible production processes.

PIGWEB – From pig to fork

The project entitled "An infrastructure for experimental research for sustainable pig production", supported by the EU Horizon 2020 aims to advance sustainable, ethical, and innovative pig production systems. By strengthening the European pig research community, the project ensures open and transparent access to experimental infrastructures and laboratories, fosters collaboration among researchers, industry, and society, and promotes harmonized standards and best practices. PIGWEB also focuses on developing novel, non-invasive methods for studying animal welfare, behaviour, and physiology, alongside creating a shared research toolbox for data-driven phenotyping and sustainability assessment. Through its emphasis on training young scientists and facilitating knowledge exchange, the project contributes to the development of a new generation of experts and reinforces Europe's capacity for responsible and high-impact agricultural innovation.

Dr. Katalin Szabó

The capability of enterprises to effectively deploy smart technologies, artificial intelligence, robotics, and algorithms in support of their operations exerts a direct influence on sustainable performance. This study demonstrates that the integration of smart technologies (STARA) with Green Human Resource Management and Green Supply Chain Management fosters waste reduction, resource efficiency, and environmentally responsible decision-making within manufacturing systems. The findings indicate that the alignment of digital transformation with green management practices simultaneously enhances organizational efficiency and environmental sustainability, serving as a critical mediating mechanism in achieving sustainable outcomes. This research aligns closely with the MATE's profile, which emphasizes sustainable innovation and responsible production systems, seeking to harmonize technological advancement with environmental sustainability.

Dr. Arnold Csonka

The study provides a thorough analysis of how incorporating circular economy principles can transform urban waste management systems in rapidly growing cities, using Indonesia as a case study. It highlights five key sectors—agriculture, energy, industry, tourism, and public services—where circular approaches can decrease waste, boost resource efficiency, and encourage community involvement. The findings stress that adopting circular models not only reduces environmental and public health risks linked to open dumping but also enhances local economic resilience. This publication offers valuable insights into practical ways to implement circular economy principles in developing urban areas, directly supporting SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

SDG 13

Climate Action

SDG 13 - Climate Action focuses on taking urgent action to combat climate change and its impacts by strengthening resilience, reducing greenhouse gas emissions, and integrating climate measures into policies and planning. The Hungarian University of Agriculture and Life Sciences (MATE) actively contributes to this goal through interdisciplinary research, innovation, and education aimed at understanding and mitigating climate risks. MATE's scientists investigate climate-smart agricultural practices, renewable energy solutions, carbon sequestration, and ecosystem-based adaptation strategies to enhance both environmental sustainability and socio-economic resilience. The University also engages in modeling climate impacts on agriculture and rural communities, providing evidence-based recommendations for policymakers and stakeholders. By fostering collaborations with national and international research institutions, MATE supports the development and dissemination of innovative technologies and strategies that reduce emissions and improve adaptive capacity. Through its commitment to climate research, sustainability education, and applied solutions, MATE contributes to the global effort to achieve SDG 13, promoting resilient agricultural systems and climate-informed decision-making that benefit both local communities, broader society and ecosystems.

66
Publications

301
Citations

Research contribution to SDG 13

In 2024, the MATE demonstrated active involvement in SDG 13 (Climate Action) research. According to Scopus data, the University produced 66 publications in this area, which collectively received 301 citations. These metrics highlight MATE's contributions to advancing climate-smart agriculture, renewable energy solutions, carbon management, and resilience strategies, emphasizing the University's role in practical approaches that support climate action objectives.

Invasive plant species pose significant challenges to ecosystems, agriculture, and human health, particularly as climate change alters habitat conditions and species distributions. Related

to this issue Knolmajer et al. (2024) provided a comprehensive overview of Ambrosia artemisiifolia (common ragweed), examining its biology, ecology, rapid expansion across Europe, and the health and agricultural risks it generates. The authors detail the plant's morphology, life cycle, allelopathic effects, and environmental preferences, emphasizing factors that contribute to its invasive success. Understanding and managing the spread of ragweed is increasingly critical, as climate change facilitates its proliferation and amplifies its negative impacts. The study highlights the importance of informed monitoring and intervention strategies to maintain ecosystem resilience, mitigate public health risks, and support adaptive responses to climate-driven ecological changes.

Climate change poses significant risks to agricultural productivity and farmers' livelihoods worldwide, necessitating effective adaptation and mitigation strategies. Hilmi et al (2024) investigated the role of circular economy and sustainable agricultural practices in enhancing farmers' resilience to climate change across both developed and developing countries. The study identifies key factors including farmers' awareness, knowledge, and skills, as well as the impact of farmland size, income risks, and access to training and extension services. The authors highlight that while both groups of countries face challenges such as economic uncertainty and legislative issues, farmers in developing countries often encounter significant upfront costs when adopting sustainable practices. The research emphasizes the importance of financial access and policy incentives in supporting the transition to sustainable agriculture, particularly for farm households.

Forests play a crucial role in mitigating climate change and advancing sustainable development goals (SDGs). In their 2024 study, Raman et al. systematically examine the contributions of forestry science research to the SDGs, focusing on its interdisciplinary impact. Analysing over 39 000 publications since 2015, the study identifies significant intersections between forestry sciences and SDGs, particularly SDG 13. The findings highlight forestry's role in carbon sequestration, biodiversity conservation, and ecosystem services, emphasizing its importance in climate change mitigation and adaptation strategies. This research contributes the necessity of integrating forestry science into broader sustainability efforts to effectively address climate challenges.

LIFE Co-Clima - Community Climate Resilience Gardens

The project focuses on strengthening community resilience and climate change adaptation in small rural settlements through participatory learning and sustainable food production. In the villages of Püspökszilágy and Penc, two demonstration vegetable gardens are established to showcase and teach how local, chemical-free, and seasonal food can be produced and processed using both traditional and innovative agricultural techniques. Beyond cultivation, these gardens serve as community spaces fostering cooperation and environmental awareness. The food produced will be used in local public catering and community events, promoting healthy, locally sourced nutrition. The initiative aims to inspire residents to adopt sustainable gardening practices that regenerate rather than deplete the soil, demonstrate natural methods of food preservation, and encourage circular use of nutrients and raw materials while minimizing waste—contributing to long-term environmental and social sustainability at the local level.

Dr. Mihály Zalai

The study investigates the connection of various farming techniques and environmental factors and the weeds community in Phalaris canariensis (Canary grass) fields. The examination of the reaction of weed flora to these factors, the research helps the understanding the cropping systems and improve them more resilient to challenges brought by climate change. The findings show that better weed management can result a reduced need for chemical use. This work supports the stability of farming systems facing an unpredictable climate by encouraging a healthier ecological balance in crop fields. Overall, the study offers practical solutions to make agriculture more sustainable and better prepared for future climate conditions. This is an important step towards tackling climate change.

Dr. Norbert Bozsik

The aim of the study was to investigate how changing climate conditions affect the performance and long-term efficiency of photovoltaic systems in the Carpathian Basin. Using RCP-based climate projections and energy yield simulations, their study quantifies the expected changes in solar radiation and temperature that affect electricity production. The results provide valuable guidance for the development of adaptive and climate-resilient solar infrastructures, increasing the reliability of renewable energy integration. Through evidence-based modeling, the research supports the transition to a sustainable and low-carbon energy future.

Dr. Anna Szabó

Mushroom cultivation is an important branch of the agricultural industry, and global mushrooms production has increased more than sixfold in the last decade. This industry uses large amounts of agricultural, forestry, livestock, and industrial wastes and their by-products. However, it also generates millions of tons of spent mushroom compost (SMC), which has emerged as a significant issue that hinders the growth of the mushroom business and impacts the environment. The generated SMC can potentially be recycled into the agricultural process by being used as a soil conditioner, an organic fertilizer, and suitable medium for growing various vegetable crops. The application of SMC has been found to be beneficial in the control of crop diseases by inducing microbiostasis, direct toxicity, or by inducing systemic resistance of the host plant, or as a soil amendment to add nutrients and restore soil fertility in agricultural lands. There are safe methods for reusing, recycling, and integrating SMC into a circular economy that reduces its negative environmental effects and carbon footprint impacts.

SDG 14

Life Below Water

SDG 14 – Life Below Water focuses on conserving and sustainably using the oceans, seas, and marine resources, which are essential for global biodiversity, climate regulation, and food security. The Hungarian University of Agriculture and Life Sciences (MATE) contributes to this goal through multidisciplinary research addressing the ecological health of aquatic ecosystems, sustainable aquaculture, and the reduction of water pollution from agricultural and industrial sources. Researchers at MATE explore innovative water management practices, the monitoring of aquatic biodiversity, and the development of technologies that support cleaner and more resilient freshwater and marine environments. The University's work also extends to studying the effects of climate change on aquatic habitats and promoting responsible fishery management and blue economy strategies. Through scientific collaboration, education, and technology transfer, MATE plays a key role in advancing sustainable aquatic resource use and supporting the long-term protection of water ecosystems in line with the principles of SDG 14.

Research contribution to SDG 14

30
Publications

285
Citations

In 2024, the Hungarian University of Agriculture and Life Sciences demonstrated active engagement in research related to SDG 14 (Life Below Water). According to Scopus data, the University produced 30 publications in this field, which collectively received 285 citations, reflecting both the productivity and growing recognition of its aquatic and environmental research.

Sustainable food production increasingly depends on finding alternative protein sources that reduce environmental impact and ease the pressure on aquatic ecosystems. In this context, Hancz et al. (2024) provide an in-depth review of how insects can contribute to sustainable feed production for aquaculture and agriculture. Their work explores the nutritional value,

production efficiency, and ecological benefits of insect-based feeds, emphasizing their role in lowering reliance on traditional fishmeal and fish oil, which often drive overfishing and marine habitat degradation. By highlighting circular resource use and reduced environmental footprints, the study aligns strongly with this SDG, demonstrating how innovative, land-based protein alternatives can support healthier marine ecosystems.

In the context of rising global seafood demand and growing scrutiny of aquaculture's environmental and societal impacts, the study by Budhathoki et al (2024) examined how public perceptions of aquaculture are shaped via scientific literature and media representations. The authors conducted scoping review and media analysis of newspaper articles across eight countries to identify key thematic clusters such as social acceptability, sustainable aquaculture, and media coverage of aquaculture. Their findings reveal that perceptions vary widely among stakeholders—including farmers, policymakers, environmental NGOs, and consumers—and are influenced by factors such as transparency, regulation, and ecological concerns. This research highlights that sustainable growth of aquaculture depends not only on technical and ecological advances but also on societal trust and awareness. By unpacking how aquaculture is portrayed and perceived, the authors stress that achieving healthy aquatic ecosystems requires both innovation and informed public engagement.

As global concerns about marine ecosystem degradation and biodiversity loss continue to grow, Soh et al. (2024) conducted an in-depth investigation into the intestinal digesta microbiota of more than 50 wild tropical marine fish species. Their analysis revealed that about 97% of the microorganisms present in fish guts remain uncultured, and that these microbial communities are clearly distinct from those found in the surrounding seawater. The study demonstrated that host-related factors, including trophic level, domestication, and phylogenetic relationships, play a dominant role in shaping microbial composition. The research's findings highlight the need to consider microbial biodiversity as a crucial element of marine conservation, showing that the stability and health of aquatic ecosystems depend not only on visible species but also on their complex, often overlooked microbial symbionts that support ecological balance.

AQUASERV - Research Services for the Blue Economy

The project, supported under the Horizon Europe programme, enables MATE to participate in an international consortium dedicated to advancing sustainable aquaculture and fisheries research. Over its five-year duration, the project aims to unite, develop, and integrate research and innovation capacities—including facilities, equipment, and expertise—across Europe. By providing transnational and virtual access to research infrastructures, AQUASERV promotes scientific progress and supports the implementation of key EU strategies such as the Common Fisheries Policy, the Farm to Fork Strategy, the Sustainable Blue Economy, and the European Green Deal. As an associated partner, MATE contributes through six distinct research infrastructures, offering advanced facilities for collaborative.

Prof. Dr. László Orbán

Researchers of MATE University use high throughput 'omics' platforms to investigate the physiology and behavior of wild and cultured fish species. We have taken part in a research collaboration that compared the microbiota of 'intestinal digesta' of over 50 tropical marine teleost species and found them distinct from that of the surrounding water. Our colleagues also analyze the interaction of feeding and behavior in native cultured food fish species of our region, including the pikeperch.

One of the aims of our aquaculture-related activities is to develop technologies that allow for chemical-free treatments of fishes infected by various pathogens. For these studies, we have used European catfish (Silurus glanis L., 1758) stocks infected with a gill monogenean (Thaparocleidus vistulensis, Siwak 1932, Lim 1996) as a model system. We have developed a minimally invasive, biopsy-based sampling protocol to estimate the ectoparasite load of infected catfish individuals and allowing for the normalization of their batches to be compared in laboratory-based experiments.

Dr. Gergő Gyalog

Our work contributed to the sustainable use of marine resources by examining how society views aquaculture, that can reduce pressure on wild fisheries and help achieve SDG 14. Having focused on the social dimension of sustainability it was highlighted that achieving sustainable aquaculture requires social acceptance and stakeholder trust, not just technical or ecological solutions. During the research it was identified how transparency, knowledge and regulation influence how people perceive aquaculture's environmental and social impacts, guiding better communication and policy. According to the study, both the media and scientific literature often simplify sustainability discussions, emphasizing the need for more balanced and informed dialogue to advance SDG 14.

Dr. Mónika Varga

As part of a long-standing collaboration with China Agricultural University, we work on the development of intensive agricultural technologies supported by process modeling. Actual research (Zheng et al, 2024) focused on optimizing energy consumption through stochastic demand-response management, achieving reductions of up to 12% in energy consumption and 18% in electricity costs. These advancements enhance the economic viability of controlled aquaculture systems, reducing reliance on wild fish stocks and minimizing environmental impacts on aquatic ecosystems. By integrating energy efficiency with resource-efficient fish and plant production, our work contributes to reducing upstream pollution and greenhouse gas emissions, supporting healthier marine and freshwater habitats. Practical facility-management solutions promote sustainable aquaculture, protect biodiversity, and help achieve SDG14 targets on responsible resource use and ecosystem conservation.

Dr. Janka Nagyné Bíró

The growing demand for animal protein, the efficient use of land and water, and the limitations of non-renewable energy sources highlight the global importance of edible insects. A recent review paper published by researchers at MATE provides a comprehensive overview of the key aspects of edible insects in sustainable feed production and environmentally friendly agriculture. Furthermore, experimental studies conducted at MATE have demonstrated that insect meals and oils can partially replace conventional fishmeal and fish oil in aquaculture without compromising growth performance, nutrient utilization, or fish health. These findings support the development of sustainable feed systems that reduce environmental impact and promote circular resource use.

SDG 15

Life on Land

SDG 15 – Life on Land focuses on protecting, restoring, and promoting the sustainable use of terrestrial ecosystems, managing forests responsibly, combating desertification, halting and reversing land degradation, and preventing biodiversity loss. The Hungarian University of Agriculture and Life Sciences (MATE) plays a central role in advancing these global goals through its multidisciplinary research and innovation in forestry, soil science, conservation biology, and landscape management. The University's work addresses key challenges such as habitat restoration, sustainable agriculture, and the integration of biodiversity conservation into rural development. Researchers at MATE contribute to safeguarding ecological resilience by developing nature-based solutions, improving land-use practices, and studying the impacts of climate change on terrestrial ecosystems. Through collaborations with international institutions and local stakeholders, MATE supports sustainable land stewardship and ecosystem restoration, ensuring the long-term health and productivity of natural environments in line with the principles of SDG 15.

102
Publications

377
Citations

Research contribution to SDG 15

In 2024, the Hungarian University of Agriculture and Life Sciences demonstrated a strong commitment to SDG 15 (Life on Land) through impactful research and scientific output. Based on Scopus data, the University produced 102 publications in this field, which collectively received 377 citations. These results highlight MATE's active role in advancing knowledge related to biodiversity conservation, sustainable land use, and ecosystem restoration. The University's work in agricultural sciences, forestry, and environmental management continues to contribute significantly to the protection and sustainable utilization of terrestrial ecosystems.

Pesticide contamination has become one of the most pressing environmental challenges, affecting not only agricultural

productivity but also the integrity of aquatic and terrestrial ecosystems. Klátyik et al. (2024) summarized evidence from 2010 to 2023 on the ecotoxicological impacts of glyphosate (GLY), its commercial formulations, and co-formulants in aquatic environments. Their work reveals that these substances, commonly used in modern agriculture, persist in surface waters and induce oxidative stress, physiological disturbances, and behavioural changes in aquatic organisms, with formulations often showing higher toxicity than glyphosate alone. The authors highlight that existing risk assessments underestimate these cumulative and long-term effects, also drawing attention to how chemical pollution in water bodies can cascade into terrestrial systems, threatening biodiversity, soil–water interactions, and overall ecosystem resilience.

Heavy metals contamination has emerged as a significant threat to terrestrial ecosystems and biodiversity worldwide. Liang et al (2024) examined how incorporating functional plant traits can enhance the field-based phytoremediation of heavy metal polluted soils. Their study analyses research from 2014 to 2024 and proposes a framework using effect and response traits as early indicators of phytoremediation performance, thereby bridging the gap between laboratory studies and real-world applications. This work underlines how leveraging plant functional traits to restore contaminated soils contributes directly to conserving, restoring and sustainably managing terrestrial ecosystems by enabling healthier soils, improving biodiversity and supporting resilient land use.

Metal and metalloid contamination of soils poses a major environmental threat, undermining ecosystem health and agricultural productivity. Sarraf et al. (2024) explored the potential of biochar—a carbon-rich material obtained from biomass pyrolysis—as a sustainable solution to alleviate metal and metalloid stress in plants. Their analysis details how biochar can immobilize toxic ions, enhance soil nutrient balance and structure, and strengthen plant defense systems, thereby reducing the uptake of harmful elements. The study highlights biochar's role in promoting soil restoration through environmentally friendly remediation strategies.

Biodiverza+- European Partnership for Biodiversity

Biodiversity loss is one of the most pressing global challenges, threatening ecosystems, economies, and human well-being. In response, Biodiversa+ was established as a new European partnership dedicated to advancing impactful biodiversity research and fostering stronger links between science, policy, and practice. Jointly developed by BiodivERsA and the European Commission under the EU Biodiversity Strategy for 2030, the initiative aims to put Europe's nature on a path to recovery by 2030 and achieve harmony between people and nature by 2050. Bringing together 74 funding organizations and policy actors from 36 countries, Biodiversa+ supports coordinated research and innovation, harmonized biodiversity monitoring, nature-based solutions, and knowledge-based policy support. Its overarching mission is to strengthen the relevance and global impact of European biodiversity research in driving transformative change.

Dr. Szandra Klátyik

Although glyphosate is the world's most widely used herbicide due to its water solubility and low persistence, serious concerns have emerged about the environmental and human health impacts of glyphosate-based products. Our work clarified that much of the toxicity of certain formulations originates from co-formulants such as POEA, which contributed to the EU-wide ban of this surfactant, with Hungary among the first to act. At the same time, our cytotoxicity

tests demonstrated glyphosate's inhibitory effects on mammalian integrins, disrupting key cellular pathways. Moreover, our recent reviews (2023–2025) comprehensively assessed the toxicological risks of glyphosate-based herbicides for ecosystems and human health. Overall, our research advances SDG 15 by supporting biodiversity protection, reducing chemical burdens, promoting sustainable agriculture, and informing evidence-based policy making.

Dr. András Neményi

Soil safety constitutes one of the fundamental elements underpinning sustainable plant production. The identification of consistent plant physiological and ecological indicators facilitates the assessment of soil heavy metal contamination risks and the prediction of plant heavy metal accumulation levels. Such methodologies prove crucial for bridging results across different scales and environments, including individual versus community levels and laboratory versus field settings.

Dr. Iman Mirmazloum

The review was formed and synthesized by an international team of researchers to highlight the detrimental effects of heavy metal/metalloid contamination on plant growth and physiology and to shed more lights on unique properties of biochar that enable it to immobilize and reduce the bioavailability of toxic contaminants in soil. A wide range of literatures were surveyed to cover the mechanisms associated with Biochar potential in efficient metal(iod)s removal through adsorption, electrostatic attraction, ion exchange, pH modification, precipitation, complexation, surface oxidation and reduction, CO_2 sequestration, slow release of nutrients, and soil microbial activities that reduce metals bioavailability and mobility in soils.

SDG 16

Peace, Justice and Strong Institutions

SDG 16 – Peace, Justice and Strong Institutions emphasizes the promotion of peaceful and inclusive societies, the assurance of access to justice for all, and the development of effective, accountable, and transparent institutions. The Hungarian University of Agriculture and Life Sciences (MATE) contributes to these objectives through its research, education, and community engagement that foster ethical governance, social responsibility, and sustainable rural development. MATE's interdisciplinary studies address issues such as equitable resource management, transparent decision-making in environmental governance, and the empowerment of local communities through participatory approaches. The University also supports capacity building and policy development that strengthen institutional resilience and promote good governance, ethical behaviour, and justice in all aspects of our academic and research effort, as well as fairness in the management of natural and social resources. Through collaboration with international partners, MATE advances knowledge sharing and the development of governance frameworks that align with the principles of peace, justice, and strong institutions, reinforcing its commitment to the values underpinning SDG 16.

15
Publications

121
Citations

Research contribution to SDG 16

In 2024, the Hungarian University of Agriculture and Life Sciences demonstrated meaningful research activity in the field of SDG 16 (Peace, Justice and Strong Institutions). Based on Scopus-indexed data, the University produced 15 publications in this area, which collectively received 121 citations.

In a rapidly shifting global landscape where public institutions must adapt to evolving citizen expectations and digital demands, Atobishi et al (2024) investigated the role of digital capabilities in improving organizational performance within public sector agencies. Drawing on survey data from Jordan's Ministry of Justice and structural equation modelling, the authors find

significant positive relationships between investments in digital tools (such as data-driven decision making, automation, and interactive citizen communications), enhanced organizational agility, and improvements in efficiency, quality, and satisfaction metrics. This highlights how the integration of digital technologies and adaptive institutional responses supports transparent, accountable, and effective governance [48].

In an era where consumer trust and corporate transparency are increasingly vital, Nugraha et al. (2024) conducted a comprehensive systematic review of greenwashing practices within the food industry, examining Scopus-indexed articles. They identify deceptive claims driven by advertising, labelling, and misleading corporate communication, and highlight six major sub-themes including retail practices, corporate social responsibility framing, consumer research, supply chains, stakeholder roles, and trust dynamics. The authors' findings underscore how greenwashing undermines institutional integrity and consumer rights by distorting environmental claims and weakening regulatory oversight, thereby emphasizing the need for stronger governance frameworks and transparent accountability mechanisms in the food sector.

Ensuring transparent and accountable governance is essential for achieving environmental sustainability and public trust. In this context, Kálmán et al (2024) explored the relationship between perceived corruption and green transition indicators across 41 countries. Their analysis reveals that stronger environmental policy performance and active international cooperation are associated with lower levels of perceived corruption, while higher greenhouse gas emissions tend to increase corruption perceptions. The study highlights that reducing corruption and strengthening institutional frameworks are crucial steps toward advancing green transition efforts and fostering sustainable, trustworthy governance systems.

Dr. Zsombor Boromisza

The Assessment of Landscape Identity project illustrates how scientific research can simultaneously advance knowledge and strengthen democratic processes. Its outcomes reach far beyond mapping or aesthetics—they contribute to the social fabric of sustainability by connecting people emotionally and intellectually to their environment.

The study shows that when citizens are invited to take part in the identification and valuation of their landscapes, they become co-owners of sustainable development. This co-creation model is a practical expression of the values embedded in the Sustainable Development Goals, particularly SDG 16.

Dr. Brigitta Szőke

The study explores the relationship between perceived corruption and green transition indicators, demonstrating that effective environmental policy and renewable energy development contribute to reducing corruption. Results show that environmental indicators explain nearly 70% of the variation in perceived corruption, highlighting the strong link between institutional transparency and environmental performance. The research emphasizes that transparent, loophole-free environmental regulation can serve as a powerful tool for corruption prevention. It supports an integrated approach between SDG 16 (Peace, Justice and Strong Institutions) and SDG 13 (Climate Action). The findings reinforce MATE's sustainability profile by underscoring the importance of strong and transparent institutions in achieving a successful green transition.

Dr. István Valánszki

This research relates to SDG 16 (Peace, Justice, and Strong Institutions) because it highlights how armed conflict in Colombia—particularly between the FARC and the Colombian army—affected both communities and the environment. The research demonstrates that periods of violence were linked to ecological degradation, while peace negotiations and agreements led to environmental recovery, emphasizing the positive role of peace in sustainable development. By connecting peacebuilding efforts with environmental restoration, the findings support SDG 16's goal of promoting peaceful and inclusive societies and building strong institutions capable of sustaining peace and protecting natural resources.

MATE 2030 Strategic Programmes

The mission of MATE 2030 is to embrace the increasing significance of agriculture and play a proactive role in advancing Hungarian agriculture as a dynamic university. We strive to bridge the gap between international scientific advancements, Hungarian farmers and industry, disseminating cutting-edge knowledge to every corner of the country and fostering new opportunities for rural development.
Our strategy is focused on five key areas:

- Educating the future generation of agricultural leaders,
- Innovative knowledge generation in the Carpathian Basin,
- Strengthening knowledge-intensive agriculture, enhancing national competitiveness,
- Making an impact to build a green future,
- Uniting the agricultural community, promoting rural-urban cohesion.

Student Mentorship Program

Project Leader: Dr. Anikó Andrea Bencéné Fekete

The Student Mentorship Programme of MATE is a unique initiative designed to support students at critical points in their academic and professional journey. By providing personalized mentorship, the program motivates students, helps them define and achieve their goals, and strengthens their sense of belonging to the university community. Mentorship participation is voluntary or recommended by instructors, with special attention given to students at risk of dropout. Participating mentors receive targeted methodological training that enhances both their mentoring and teaching skills, extending the program's positive impact to the wider educational culture.

Since its launch, the program has supported over 200 students across 13 institutes, guided by 13 lead mentors and 34 faculty mentors. Notable outcomes include a 92% improvement in students' academic performance, a 79% increase in credit completion rates, and a 19% rise in scholarship averages. Students mentored for a year achieved even greater success, with credit completion improving by 30% and corrected credit index increasing by 71%. Beyond measurable results, the mentorship ethos has been integrated into the university's teaching practices.

The program offers individualized attention, targeted guidance, strong student–faculty relationships, a supportive and mentally safe environment, and encourages more deliberate academic planning. Long-term, the Mentorship Program enhances MATE's competitiveness by supporting student recruitment and retention, fostering engagement, promoting degree completion, and contributing to the international recognition of its diplomas. Ultimately, it builds an inclusive, modern learning environment where every student can thrive.

Future Leaders Programme

Project Leader: Dr. Katalin Szabó

The Future Leaders Programme (JVP) is an innovative talent development initiative designed to cultivate the leadership skills and career potential of students. Its mission is to prepare a new generation of leaders who are globally competitive in mindset, skills, and achievements, while promoting MATE's values and contributing to national development. Participants gain access to exceptional domestic and international professional experiences, develop multidisciplinary knowledge, and build valuable networks to advance their career goals. The program equips students with leadership competencies that are not typically offered in regular coursework, enhancing their distinction among peers and the value of their degrees.

JVP offers four distinct career pathways aligned with MATE's strategic areas: Academia, Innovation, Management, and Policy & Governance. Each pathway provides tailored training, mentoring, and project-based experiences led by expert mentors, supporting students in developing specialized knowledge, critical skills, and hands-on experience in their chosen field. The program provides financial support in the form of a monthly scholarship, which allows students to focus on their personal and professional growth, and participation can count as up to 10 academic credits.

Structured in three phases—orientation and goal setting, professional immersion, and evaluation—the program emphasizes both leadership and professional development. Students engage in career-path-specific projects, masterclasses, team-building activities, English-language training, and mentoring, culminating in a closing conference and celebration. By fostering leadership, international competitiveness, and practical expertise, the JVP prepares participants to become influential contributors to society, the knowledge economy, and the global agricultural and life sciences sectors.

MATE Alumni Program

Project Leader: Barbara Lapu-Balogh

The MATE Alumni Program fosters lifelong connections with graduates who have shaped their professional fields nationally or internationally. The program maintains an active and engaged alumni network, offering opportunities for professional development, community engagement, and continued connection with the University. Its central hub, the alumni.uni-mate.hu website, provides information, services, and a platform for alumni to reconnect with peers and the University.

The program focuses on two main pillars: career and professional support, including mentoring, shadowing, and specialized training, and community-building activities such as events, campus programs, and targeted communications. Alumni benefit from regular newsletters, exclusive alumni discounts, recognition at milestone graduation anniversaries, networking and gala events, and inspirational video portraits highlighting alumni career paths. Participation also allows alumni to guide current students through mentoring and job-shadowing opportunities, strengthening professional ties and knowledge transfer.

Since its launch, the program has registered over 2,500 alumni, produced more than 30 video portraits, facilitated 40–50 events annually, maintained 17 active alumni benefits, and appointed five alumni campus ambassadors. By connecting past and present members of the MATE community, the Alumni Program supports lifelong learning, enhances the University's reputation, and fosters a dynamic, engaged, and collaborative professional network.

MATE Teaching Awards

Project Leader: Dr. Márta Balláné Erdélyi

In spring 2024, MATE launched the Teaching Awards as part of the MATE 2030 strategy. The program recognizes outstanding educators who demonstrate professional excellence, commitment, and innovation, contributing significantly to raising the quality of teaching at the University. The awards celebrate colleagues who define the success of MATE's education and serve as an inspiration for the academic community.

The awards aim to make exceptional teaching visible, enhance the effectiveness and quality of education, encourage professional dedication, and support the development of future agricultural experts through exemplary mentorship. They are presented in five categories: the KATEDRA Award for lifetime achievement, the ETALON Award for the Teacher of the Year, the START Award for outstanding young educators, the MAGISTER Award for excellence in

student mentoring, and the COMPASS Award for innovative teaching practices.

The nomination and evaluation process is rigorous. Each year, MATE institutes and, in the case of the ETALON Award, the Student Union nominate candidates. A nine-member faculty committee ranks nominees, and students vote on a shortlist of four finalists per category. Selection criteria include measurable professional achievements, student feedback, and exemplary teaching practices.

Strategically aligned with the MATE 2030 goals—particularly the Digital Transition and Efficiency pillar and performance-based culture—the Teaching Awards enhance educators' professional recognition, motivation, and workplace satisfaction, while strengthening the University's institutional prestige. Beyond recognition, the program fosters an inspiring, supportive, and development-focused academic community.

Renewal of Adult Education

Project Leader: Dr. Krisztina Tóth

At MATE, the renewal of adult education is not just a response to change, but a proactive step toward shaping the future of learning. As part of the MATE 2030 Strategy, the Programme aims to build a diverse, practice-oriented, and market-relevant training portfolio that promotes lifelong learning and opens new pathways for professional development.

Drawing on MATE's decades-long experience in adult education, its extensive national network, and its strong ties to the Hungarian agricultural sector, the renewed portfolio offers a wide range of training opportunities — from agritech and digitalization to professional and corporate training. The program is designed to meet the needs of multiple target groups, including prospective university students, working professionals, agricultural practitioners, and lifelong learners. Courses range from university preparatory and drone technology modules to agricultural consultancy, management training, and specialized professional certifications.

Alongside the renewal of its training offer, MATE is modernizing the entire adult education ecosystem. A new visual identity and digital application platform ensure a streamlined learner experience, while a refreshed recruitment strategy and strong partnerships foster dialogue-based program design. The initiative also supports the internationalization of curricula, with new programs such as the Agritech Management course. Through this comprehensive renewal, MATE promotes flexibility, practical expertise, and sustainable knowledge - supporting lifelong learning in service of innovation and a more resilient society.

SMART UNI

Project Leader: Prof. Dr. Zoltán Bujdosó

The SMART UNI – Teaching Compass programme represents a new milestone in the university's commitment to high-quality, digitally supported education. Closely aligned with the MATE 2030 Strategy, the initiative aims to strengthen teaching excellence and innovation, ensuring that graduates are not only professionally skilled but also adaptable, socially responsible, and capable of contributing to sustainable and value-driven development.

In a rapidly changing higher education landscape shaped by digitalization, globalization, and diverse student expectations, MATE recognizes that teaching quality development must go beyond control mechanisms. The Teaching Compass approaches professional growth as a supportive and reflective process, built on constructive feedback and mutual learning. It provides a structured yet flexible framework that encourages educators to improve continuously while contributing to institutional quality enhancement.

As a digitally supported system, the Teaching Compass integrates multiple perspectives – from students, peers, and academic leaders – to offer a comprehensive view

of teaching practices. Student feedback reveals how learning experiences are perceived, while peer reviews promote knowledge sharing and the identification of best practices. Leadership perspectives ensure alignment with institutional goals and quality assurance standards. The system's visual feedback tools make results clear and actionable, allowing teachers to recognize their strengths and development areas, and helping the university monitor long-term trends in teaching excellence. Ultimately, SMART UNI – Teaching Compass fosters a culture of collaboration, reflection, and continuous improvement that empowers educators and enhances the overall quality of education at MATE.

MATE Impact Awards

Project Leader: Dr. Dávid Papp

The MATE Impact Awards, established as part of the MATE 2030 strategy, recognize staff members whose work creates measurable societal, environmental, and economic impact beyond the University. These awards highlight the importance of translating knowledge into real-world action and mark a pioneering step in the Hungarian higher education sector, as MATE is the first university in the country to formalize recognition for "third mission" achievements. The program emphasizes that impact outside the classroom and laboratory is as valuable as traditional research and teaching performance.

The awards cover four categories, celebrating innovation, public engagement, sustainability, and community-building. The Innovation Impact Award honors those whose creative projects and research deliver practical solutions with societal or environmental relevance. The MATE Media Ambassador Award recognizes colleagues who effectively communicate the University's mission and achievements to the public. The Sustainability Award celebrates efforts in environmental stewardship and responsible practices, while the Agóra Award highlights initiatives that foster inclusive, collaborative, and intellectually vibrant communities within and beyond the campus. Together, these awards promote a culture of responsibility, engagement, and visible impact.

Each year, the winners are celebrated at a formal gala dinner, receiving both public recognition and a monetary prize. Since its inception in 2024, the Impact Awards have strengthened MATE's reputation as a socially responsible institution, inspiring staff to extend the University's influence beyond its walls. By integrating societal contribution into academic life, the program encourages a culture where innovation, sustainability, and community engagement are fundamental values, shaping MATE as a leading institution committed to meaningful, real-world impact.

Flagship Research Groups and Research Excellences Programmes

Project Leader: Prof. Dr. Zoltán Kovács

As one of the pulling initiatives of the MATE 2030 Strategy, the Flagship Research Groups (FRGP) and Research Excellence (REP) Programmes represent key pillars of research excellence at MATE. These programmes aim to identify, support, and empower the University's most outstanding researchers and research teams, both nationally and internationally. By introducing a transparent, performance-based support system, they foster a culture of excellence and lay the foundation for long-term scientific competitiveness.

The programmes focus on research areas of strategic importance, such as sustainable agriculture, food security, climate adaptation, digitalization, and interdisciplinary innovation. They support projects that contribute to the United Nations Sustainable Development Goals, from optimizing food supply systems and enhancing environmental monitoring to promoting circular economy solutions and biodiversity conservation. The FRGP provides three-year

institutional support for 15–20 research groups with significant scientific achievements and high-impact projects, while the REP offers two-year individual grants to around 70-80 researchers demonstrating outstanding performance in their respective fields.

Beyond financial support, both programs emphasize professional development, community building, and international collaboration. Through continuous training, mentoring, and visibility efforts, they strengthen research careers from junior scientists to leading group heads. Their impact extends well beyond academia — enhancing Hungary's knowledge-based economy, strengthening international partnerships, and improving MATE's global standing in university rankings. Ultimately, the FRGP and REP embody the University's commitment to scientific excellence, innovation, and societal relevance, ensuring that individual success translates into institutional and national advancement.

Innovation Competitiveness Diagnostics

Project Leader: László Nagy

This initiative at MATE serves as a strategic instrument to strengthen the University's research and innovation excellence. Its primary goal is to identify MATE's key research and innovation focus areas by aligning internal academic strengths with external funding and partnership opportunities. Closely linked to the Research Excellence (REP) and the Flagship Research Groups (FRGP) Programmes, the project supports the University in shaping the future of MATE and contributing to sustainable national and international impact.

Given MATE's multidisciplinary profile and multi-campus structure, a coordinated and evidence-based strategy is essential. The diagnostics process provides a comprehensive framework to guide institutional decision-making, define scientific priorities, and enhance competitiveness in both the domestic and global research landscape.

Through the mapping of institutional expertise, the identification of synergies across departments, and the establishment of innovation portfolios, the diagnostics initiative enables MATE to build a coherent and forward-looking research ecosystem. By integrating academic excellence with applied innovation, it supports the University's mission to deliver high-impact, sustainable solutions for the agricultural, environmental, and life sciences sectors.

MATE 100 Club

Project Leader: Andrea Virág-Várhidy

The MATE 100 Club is a strategic initiative, designed to establish long-term, mutually beneficial partnerships with 100 key stakeholders, including leading market actors and professional associations. Its primary goal is to connect university knowledge with industry needs, fostering innovation, knowledge transfer, and collaborative projects that generate economic, social, and environmental impact.

The MATE 100 Club provides tangible benefits, including scholarships, dual training programs, professional internships, infrastructure development, academic–industry research careers, collaborative grant applications, and corporate continuing education. Supported by a robust database of key contacts, targeted communication, and regular high-profile events, the Club strengthens the university's position as a central hub in the agricultural innovation ecosystem, fostering international visibility, sustainable collaboration, and a new generation of industry-ready graduates.

Since its inception, the Club has organized several landmark events to strengthen these strategic connections. The inaugural June 2024 meeting on Lake Balaton brought together top executives, researchers, and decision-makers to discuss the

future of sustainable, knowledge-based agriculture. In November 2024, a B2B business forum at the Gödöllő Royal Palace facilitated 175 project presentations and 110 business meetings, resulting in immediate collaborative initiatives, dual training programs, and research partnerships. In May 2025, the Club celebrated its first anniversary with a river cruise in Budapest, reinforcing past achievements and exploring future opportunities for knowledge-based growth.

The Flagship Research Groups Programme

One of the main objectives of MATE is to support the achievement of the UN's Sustainable Development Goals. To this end, various programs are designed and implemented to reinforce the research activities in defined strategically important areas. These include programmes established to enhance research and publishing performance, as well as to increase the international visibility of MATE.

The Flagship Research Groups Programme, developed based on the experiences of the Research Excellence Programme launched as a pilot in 2023, is one of the most important representatives of these programs. This initiative aims to support outstanding researchers who are organized into groups or already working in research groups in strategic priority areas, and, among other supports, to provide them with financial resources to accelerate their further scientific advancement during the three-year funding period.

The Programme strives to establish and operate research groups that evolve along a trajectory making them capable of acquiring international research grants, thereby ensuring greater self-sustainability of our University. Further goals of the Programme include enhancing the creation of high-quality publications and intellectual property rights, ensuring academic post-graduate education through high-quality and more sustainable research, and increasing the international reputation of the University. Moreover, the activities aim to contribute to sustainable development while influencing the progress of the local and international economy, social welfare, and a knowledge-based future.

The main elements of the three-year funding period are annual financial and administrative support. In addition, the program supports professional community building, provides trainings and workshops for developing hard and soft skills, and offers opportunities to participate in consultations on the university's scientific strategy. Information and results about the 13 groups of the first cohort can be found on the programme's website.

Agri-Food By-product Valorisation Research Group

Research Group leader: Prof. Dr. László Abrankó

The "Agri-Food By-product Valorisation Research Group" at MATE focuses on advancing knowledge across food, feed, and soil sciences by exploring innovative, multi-purpose uses of food-processing by-products. Rather than simply upcycling waste, the group emphasizes comprehensive valorisation—extracting valuable fractions such as polyphenols and then finding ways to utilize the remaining secondary by-products. Through an integrated, interdisciplinary approach, the team applies these research findings to food, feed, and soil applications, promoting circular economy principles within agricultural systems. Under the leadership of Prof. Dr. László Abrankó, the group combines expertise in food analysis, bioactives, and regenerative soil management, contributing to sustainable and resource-efficient agri-food systems. The research directly supports several United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land).

Femtoscopy Research Excellence Group

Research Group leader: Prof. Dr. Tamás Csörgő

The "Femtoscopy in CMS at LHC and PHENIX at RHIC – with Practical Applications" research group at MATE focuses on advancing fundamental knowledge

in high-energy physics, with a special emphasis on femtoscopy—the study of matter at the smallest measurable scales, both in space (10^{-15} m) and time (10^{-23} s). The group actively participates in two world-leading experiments: PHENIX at the Relativistic Heavy Ion Collider (RHIC) in the United States and CMS at the Large Hadron Collider (LHC) at CERN in Europe. Their research contributes to understanding the fundamental structure of matter and the dynamics of subatomic particles, while also producing numerous high-impact scientific publications.

Beyond pure physics, the group pioneers innovative interdisciplinary applications, such as developing proton holography, a novel 3D imaging method using proton waves—an unprecedented step toward visualizing elastic proton-proton interactions. They also explore the use of femtoscopic, model-independent analytical methods in food science and economic systems, broadening the impact of fundamental research to practical, real-world contexts. In addition, the group promotes open science through creating a digital archive of the works of renowned physicist V. N. Gribov, and through educational gamification tools like science-inspired card games and Rubik's cubes.

This unique combination of cutting-edge research, innovation, and public engagement supports several UN Sustainable Development Goals (SDGs), including SDG 4 (Quality Education) and SDG 9 (Industry, Innovation and Infrastructure).

Circular Tourism Research Group

Research Group leader: Prof. Dr. Lóránt Dénes

This project contributes to SDG 11 (Sustainable Cities and Communities) by examining ways to enhance the liveability and resilience of both rural and urban areas through sustainable tourism and circular economy practices. It promotes SDG 12 (Responsible Consumption and Production) by identifying models of resource efficiency and waste reduction that can be integrated into tourism and local development strategies. The project also aligns with SDG 8 (Decent Work and Economic Growth) by emphasizing green innovation and sustainable entrepreneurship in the tourism sector, supporting inclusive economic growth while preserving cultural and natural heritage.

Through interdisciplinary research, the programme connects SDG 13 (Climate Action) by highlighting the role of scientific tourism in raising awareness about environmental issues and encouraging low-carbon lifestyles. It further supports SDG 9 (Industry, Innovation and Infrastructure) by fostering innovative approaches to sustainable tourism infrastructure and digital solutions that strengthen rural–urban linkages.

Overall, the project's findings provide practical recommendations for integrating sustainability principles into tourism, education, and community development. By combining scientific research with real-world applications, the programme helps create pathways toward a greener, more inclusive, and circular future that benefits both people and the planet.

Molecular Genetics of Fruit Trees Research Group

Research Group leader: Prof. Dr. Attila Hegedűs

We have carried out molecular genetic studies on diverse fruit and ornamental species, including Cornus mas, Prunus laurocerasus and other Prunus secies, and Malus domestica, employing various marker systems (SCoT–FaSt, SSRs, and S-allele genotyping) to assess genetic diversity, phylogenetic relationships, and breeding potential. These investigations contribute significantly to the conservation and sustainable utilization of plant genetic resources, aligning with several United Nations SDGs.

A novel SCoT–FaSt marker system was developed to explore genetic diversity in various Prunus species. The integration of a newly developed transposon-based

primer (FaSt-R) enhanced polymorphism detection and phylogenetic resolution. The identification of FaSt elements in gene-rich regions of the Prunus genome and their differential distribution between subgenera suggests a role in evolutionary divergence. This work supports SDG 15 (Life on Land) by promoting biodiversity conservation and its application through improved genetic characterization tools.

Our study on cornelian cherry (Cornus mas) revealed high genetic variability among 50 accessions using SSR markers. The identification of distinct genetic clusters, especially among yellow-fruited cultivars and Hungarian landraces, highlights the importance of preserving local germplasm. These findings are directly relevant to SDG 2 and SDG 15, as they provide a foundation for breeding resilient cultivars and conserving agrobiodiversity.

The molecular analysis of cherry laurel (Prunus laurocerasus), a highly polyploid species was focused on ornamental and fruit-bearing accessions. The applied SSR and S-RNase markers revealed significant genetic differentiation between ornamental and fruit-bearing groups, reflecting divergent selection pressures. The study's novel fingerprinting data support breeding and conservation efforts, contributing to SDG 12 and SDG 15, by enabling sustainable cultivar development and genetic resource management. The inclusion of minor fruit crops can positively contribute to making a healthy diet more accessible to a broader population, which is also relevant for SDG 3.

Our first-year study also included the examination of red-fleshed apple hybrids, in which we optimized S-allele genotyping to assess pollination compatibility and validate breeding records. The discovery of unique allele distributions and potential segmental duplications in heritage cultivars underscores the importance of molecular tools in breeding programs. This research supports SDG 3 through the development of nutritionally enhanced fruit varieties, and SDG 9 by refining genotyping methodologies for agricultural innovation.

Collectively, these studies demonstrate the critical role of molecular genetics in sustainable horticulture (and specifically in the fruit-growing sector), conservation, and breeding. They provide practical insights for enhancing food security, preserving biodiversity, and fostering innovation in plant science, all of which are crucial to achieving the mentioned Sustainable Development Goals.

Horticulture Research Group

Research Group leader: Prof. Dr. Lajos Helyes

The research group aims for growing technology development with the objective of enhancing nutrition value of different fruit and vegetable species. Horticultural products considered general source of healthy food for people but also provide livelihood for families. The role of horticultural production on a small scale attached to the rural region of Hungary contribute to SDGs of "no poverty", "zero hunger", "global health and well-being" or "even climate action". In some underdeveloped rural regions gardening contribute to self-sufficiency and offer the opportunity to people living in the rural regions to access nutritious fruits and vegetables as source of vitamins, micro- and other phytonutrients such as carotenoids, anthocyanins, phenolic compounds etc. In Hungary, there is big potential for improvement in large-scale horticulture as well. The changing climate affect small- and large-scale horticulture as well. The negative effects can be mitigated if we adapt the genetic background and growing technologies to the drying growing seasons, heat waves, new arrivals of pests or phytopathogens and so on.

Adaptive and sustainable irrigation technologies are key focus in the research group. The experiments cover the topics of the effect of different water supply levels on health-supporting phytonutrient compounds, improving water productivity or the evaluation of

plant water stress. The emergence of vertical farms carries high development and innovation potential and may have a key role in shortening the supply chain for sustainable cities in the future. Our research focuses on the development of efficient lighting practices that are also support improved nutrition values of different microgreen species. As mushroom production is being a successful sector in Hungary it also faces new challenges regarding pathogens, raw material, harvesting techniques that need to be solved by improving the growing technology.

All of the research group members continuously implement their recent findings into the training of agricultural and horticultural engineers maintaining the quality education goals of the University. The novelties should be shared with the wider public also to enhance the spread of good practices nation-wide.

Research Group on Fish Welfare and Security of Fish Production

Research Group leader: Dr. Ákos Horváth

The research group's objective is to enhance fish welfare and the security of fish production in aquaculture systems, encompassing both farmed and natural fish stocks. This endeavour is driven by world-leading, pioneering research. The group seeks to achieve significant advancements in fish breeding, reproduction, nutrition, and culture technology, while considering sustainability, the transition to a circular economy, and the One health approach. The group's goals will be achieved through the testing of innovative feeding regimes, including alternative feed ingredients. Additionally, the group will assess the impact of these feeds on the external and internal environment of fish, encompassing the system microbiome, intestinal and gonadal microbiota, stress levels, and gamete quality. Furthermore, the group will develop alternative reproductive methods, such as surrogate production and the culture of gametes, to enhance the security of fish production in aquaculture.

Aquaculture is a rapidly evolving sector that has experienced a remarkable 14-fold increase in production over the past 35 years, a trend that appears to be continuing. In addition to this significant increase in production, there has been a recent shift in the focus of both farmers and consumers towards the concept of the "One health" policy. This policy emphasizes the importance of producing healthy food by ensuring that animals are raised in healthy environments. Consequently, current aquaculture research is primarily focused on enhancing fish welfare through the development of improved production technologies.

During the initial year of research, we conducted a comprehensive analysis of the quality of common carp broodstock and the microbial communities that influence it. This research employed both classical culture techniques and metagenomic analysis to achieve our objectives.

Our primary focus was on isolating bacterial strains with potential probiotic activity. Through microbiological analysis of gamete and gut samples, we determined the number of colony-forming units (CFUs) present in each sample and identified several isolates to species level. Subsequently, we optimized the growth conditions for the potentially probiotic candidate microorganisms, including determining the optimal temperature and pH, and assessing their growth vigour. Further research was conducted on African catfish. Breeders were raised exclusively on feeds supplemented with either 33% or 66% insect meal. These breeders were subsequently spawned and sampled to establish the baseline health status of insect meal-fed fish.

The work of the research group principally contributes to SDG 2 (Zero Hunger) as well as to SDGs 3 (Good Health and Well-being), 12 (Responsible Consumption and Production) and 13 (Climate Action).

One Health Research Group

Research Group leader: Prof. Melinda Kovács

Climate change affects both the availability and nutritional value of feed resources. Our project tests heat- and drought-resistant cereals and locally available protein sources. We evaluate these alternative feedstuffs by examining how more fibrous diets, together with NSP-degrading enzymes, influence digestion, gut health, and product quality. Our findings support strategies to improve feed nutritional value and feed security, which are essential for high-quality, sustainable animal production.

At the same time, we investigate echinococcosis, an emerging parasitic zoonosis driven in part by climate change and provides evidence by assessing zoonotic risk in wildlife transmission cycles. It has been confirmed that besides the rate of echinococcus infection in carnivores, and specially jackal presence, district-level socioeconomic deprivation has the strongest impact on the risk of human alveolar echinococcosis. This work supports prevention strategies for zoonoses in Hungary but also provide scientific evidence on dynamic change of ecosystem in response to climate and socio-economic circumstances.

In the field of poultry production, our research helps to clarify how targeted peri- and postnatal nutrient delivery - via in ovo and hydrogel supplementation - can enhance immune function and improve the poultry health and performance.

To better understand the growing impact of heat stress under climate change, we developed an experimental model in which we monitor the physiological status of fattening pigs and study how metabolic and environmental stress affect energy metabolism and nutrient utilization. These studies not only reveal how suboptimal environments disturb metabolism, but also support the use of pigs as a translational model for humans.

Addressing the dynamics of biotic (e.g., zoonosis) and abiotic stress (e.g., temperature) in ecosystem and farm animals' response needs multidisciplinary approach, the cooperation of nutritionists, veterinarians, medical doctors, wildlife biologists, animal breeding, and analytical experts. By applying this multi-actor approach, we also ensure gender equality, as our research group consists of four women and four men.

Climate change has a profound impact on ecosystems, increases the risk of zoonotic diseases, compromises the immune competence of animals, and strongly affects feed resources. To address these challenges, deeper understanding of emerging zoonoses and new nutritional strategies are needed. Developing and applying technologies that improve the efficiency of animal production and resource use, directly supports sustainability. By reducing the environmental footprint of livestock farming, we can mitigate greenhouse gas emissions, which in turn contributes to efforts to alleviate climate change.

Microbiome-Driven Applications for Sustainable Food Systems Research Group

Research Group leader: Prof. Dr. Quang Duc Nguyen

The group of Prof. Quang D. Nguyen focuses on advancing scientific understanding of the microbiome's role in creating sustainable and healthy food systems. The group investigates how microbial communities contribute to food safety, quality, and nutritional value, as well as how they can be harnessed for the valorisation of food waste. Through an integrated and interdisciplinary approach, the researchers explore the interactions between microorganisms and food matrices, aiming to establish data-driven, efficient, and environmentally responsible food production systems.

Microorganisms play a dual role in food technologies—while beneficial species enable the transformation

of raw materials into nutritionally rich and bioactive products, pathogenic ones pose risks to food safety. By studying these dynamics, the group aims to optimize fermentation processes and microbial applications, reducing food waste and enhancing food quality. The project also focuses on developing publicly accessible microbiome datasets, promoting open science and innovation in food research. In the long term, this work supports the creation of sustainable food value chains, reducing environmental impact and strengthening the economic resilience of the agri-food sector.

This research contributes directly to several UN Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land), by fostering healthier, more sustainable, and resource-efficient food systems.

Sym-biom Research Group

Research Group leader: Prof. Dr. Katalin Posta

The research project "Analysis of the interplay between the root system and microbiome of Legume plants: a perspective for an innovative agriculture" focuses on understanding plant-microbe interactions, applying interdisciplinary approach combining horticulture, plant production, and microbiology. The project explores how environmental stress factors and cultivation practices affect crop yield and quality, and root architecture.

Roots not only provide structural support but also mediate water and nutrient uptake, which is critical for plant growth under adverse environmental conditions. Beneficial symbiotic microorganisms, including arbuscular mycorrhizal (AM) fungi, enhance nutrient acquisition and improve plant resilience to biotic and abiotic stress. The research team investigates how root system architecture influences beneficial symbiotic interactions and the composition of root microbiome, using root developmental mutants of a model legume species. We are currently studying a mutant with impaired root development and modified symbiotic interactions, resulting in changes to the length and number of lateral roots.

Legumes are known for their high protein content due to their ability to establish nitrogen-fixing symbiosis with rhizobia. Therefore, they have a vital role in both human diet and animal feeding. In many regions, they present the primary protein source for local populations. By deepening our understanding of plant adaptation mechanisms, this project contributes to several SDGs adopted by the United Nations.

Promoting sustainable and resilient legume cultivation aligns with SDG 2 (Zero Hunger). A deeper understanding of root-microbe interactions can reduce dependence on chemical fertilizers, thereby supporting SDG 12 (Responsible Consumption and Production). This approach protects soil and water resources from the harmful effect of the excessive fertilizer use and helps maintain microbial diversity, contributing to SDG 6 (Clean Water and Sanitation) and SDG 15 (Life on Land). Reducing chemical fertilizer application also lowers greenhouse gas emissions, one of the key driving forces behind climate change, thus advancing SDG 13 (Climate Action), and enhancing resilience to environmental stress.

Educational initiatives associated with the project promote SDG 4 (Quality Education), by preparing the next generation of agricultural scientists to apply innovative and sustainable solutions.

Furthermore, the project's outcomes have implications for SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth) by supporting smallholder farmers to cultivate high-performing legume varieties. The conservation of microbial diversity and adoption of sustainable soil management practices also indirectly contribute to SDG 14 (Life Below Water) by reducing

nutrient runoff. The interdisciplinary and collaborative approach of the group strengthens research partnerships and knowledge exchange, thereby advancing SDG 17 (Partnerships for the Goals).

In summary, this research project integrates fundamental plant science with applied agricultural sustainability, contributing to multiple SDGs by promoting resilient crops, sustainable soil management, climate adaptation, and education. Its outcomes offer innovative pathways to reduce fertilizer dependency, enhance soil health, and preserve biodiversity, demonstrating a systemic approach to sustainable agriculture.

Nature Based AgriEcosystem Restoration Research Group

Research Group leader: Dr. Miklós Sárospataki

The "Tracking the Progress on Ecosystem Restoration Involving Agriculture-Related Nature-Based Solutions" research group focuses on advancing knowledge in the intersection of biology, agriculture, and ecology, with a particular emphasis on regenerative grazing as an innovative livestock management approach. This method is investigated for its potential to enhance soil health, biodiversity, and ecosystem services. The research team employs an interdisciplinary approach, bringing together zoologists, botanists, microbiologists, soil scientists, animal husbandry experts, and statisticians, along with an international partner supporting science communication and knowledge transfer.

As human activities increasingly degrade natural ecosystems, biodiversity loss and the decline of ecosystem services threaten food security and rural livelihoods. In response, nature-based solutions (NBS) offer a sustainable framework for restoring ecosystems while maintaining agricultural productivity. The group's work examines how regenerative grazing by local mixed herds contributes to biodiversity restoration, soil enrichment, and climate resilience - offering a model for sustainable agricultural practices that balance productivity with ecological integrity.

Through long-term, cross-disciplinary studies, the project contributes to a science-based understanding of ecosystem restoration and supports the development of practical guidelines for sustainable land use. Its outcomes directly align with several UN Sustainable Development Goals, including SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land).

Environmental Fate and Ecotoxicity Assessment Research Group

Research Group leader: Dr. András Székács

The "Environmental Fate and Ecotoxicity Assessment" research group at MATE focuses on advancing knowledge in environmental sciences through innovative detection and assessment methods, including induced fluorescence-based instrumentation. The group investigates the occurrence, persistence, and biological effects of inorganic and organic microcontaminants originating from agriculture or other anthropogenic sources, aiming to safeguard environmental and food safety. Their research is structured around three main directions: expanding the range of analytes detectable by laser-fluorescence instruments, evaluating the dissipation and ecotoxicity of agricultural pollutants while creating a comprehensive database for agrochemical assessment, and monitoring organic microcontaminants and potentially toxic elements in waste management systems to support circular economy approaches.

In addition, the group develops novel enzyme-linked fluorescent immunoassays optimized for aquatic media, enabling highly sensitive detection of pharmaceuticals, pesticides, and other microcontaminants in environmental and biological samples. This interdisciplinary approach integrates chemistry, ecology, toxicology, and analytical sciences to provide

robust, actionable data for sustainable pollutant management. The research directly contributes to SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land) by improving the monitoring, understanding, and mitigation of contaminants that threaten ecosystem and human health.

Regenerative Agricultural Technologies Research Group

Research Group leader: Dr. Zoltán Tóth

In the last century, agricultural industrialisation has primarily aimed to increase productivity through chemical inputs and larger machinery. Natural and ecological resources were replaced by industrial inputs. As a consequence, nutrient cycle became more and more open, natural recycle of nutrients and organic matter was reduced. The progress in breeding and farm practices geared towards that ideal. This has come at an environmental cost that is no longer acceptable. Consequently, soil degradation became extensive, biodiversity, ecosystem service and resilience of soil got purer.

In the research project the effect of regenerative agricultural technologies applying reduced or zero tillage while providing longer mulch cover and more living root systems in the soil due to cover crop production is evaluated. During the research, we examine the soil's physical, chemical and biological properties, and we also monitor the field's water regime and climatic conditions. Productivity, physiological status (abiotic stress level) and yield quality are also analysed and compared with conventionally managed fields under different pedoclimatic conditions. In addition, the phytosanitary status will also be assessed. With this multidisciplinary approach, a complex and comprehensive research programme can be developed, providing numerous useful results.

Regenerative agriculture provides higher resilience and higher sustainability, climate neutrality in line with European policy priorities for the sector: Farm to Fork Strategy, Biodiversity strategy for 2030, upcoming Soil Strategy for 2030, and new Common Agricultural Policy for 2023-2027; all under the impetus to implement the core of the European Green Deal. It is also in accordance with the 1st and 2nd priority research areas of MATE:

- Promoting the sustainable use of natural resources, preserving biodiversity and restoring the functioning of natural ecological systems.
- Research and innovation fostering agricultural and natural ecosystems to help adapt to climate change.
- The project is linked to SDGs 12, 13, and 15, promoting responsible production, climate action, and the protection of terrestrial ecosystems.

Stress Resilience in Crop Production Research Group

Research Group leader: Dr. Éva Várallyay

The "Stress Resilience in Crop Production" research group studies the abiotic-biotic stress resilience mechanisms of plants using cutting-edge combined methodologies.

Targeting the SDG2 - Zero hunger aim, we carry out basic research, investigating the plant stress responses, alleviating the impacts of a hostile environment and optimising productivity and biological fitness. We study (i) host-pathogen interaction dynamics and defence/counter-defence strategies in natural populations, (ii) temperature dependence of virulence and disease development, (iii) transcriptional and post-transcriptional regulation of host-pathogen interaction and heat response pathways, and (iv) plant productivity changes upon virus infection, temperature stress or combined stress.

Our results were published in high-quality papers, as follows:

- We characterised the virome of cherry, sour cherry and found frequent coinfection of previously not described viruses, which could impact the tree health (Desiderio et al, 2024, D1).
- We characterised the miRNA-ome of Apple rubbery wood 2-infected apple trees, focusing on the lignin biosynthetic pathway, and confirmed that the gene-expression changes in the genes that regulate lignification cannot be directly correlated with the presence of the virus (Jahan et al, 2025, Q1).
- Cutting-edge HTS-based methods were also used to investigate viromes of solanaceous crops in Kosovo (Ismajli et al, 2025, doi.org/10.3390/plants14091273, Q1), revealing multiple infections in peppers by six plant viruses and monocotylenodous weeds in Hungary (Galbacs et al, 2024, Q1), resulting in infection by several viruses, suggesting their virus reservoir role.
- Our comparative functional analyses of the movement and coat proteins of grapevine Pinot gris virus, encoded by symptomatic and asymptomatic variants, added new insights into the symptom development in grapevine during viral infection (Jaksa-Czotter et al, 2025, Q1).
- We have investigated the role of RNA structural regulatory elements of small RNA biogenesis in the determination of loading efficiency into executor complexes, revealing that remote precursor elements can modulate RNA-induced silencing complex-loading efficiency of miR168 in Arabidopsis (Dalmadi et al, 2025, D1).
- We have studied adaptation to heat stress in Arabidopsis and have shown that (i) high temperature decreases transcription fidelity and (ii) that TFIIS and the NMD pathway cooperate to ensure transcriptome fidelity and proper alternative splicing, needed for development and heat stress adaptation (Szaker et al., 2025, D1).

Aiming SGD 4 - Quality education, in the first year of the project, 3 of our PhD and 9 MSc students defended their theses with the supervision of our team members, and presented their work at student conferences: OTDK (3 presentations) and EKÖP Conference (2 presentations). To popularise our scientific activity, we participated in the Pint of Science event, and we hosted university and elementary school students to support their career orientation.

Fulfilling SDG 5 - Gender Equality, Eva Varallyay has been elected to be the corresponding member of the HAS. Moreover, our research paper about GPGV has been published in the „Women in Plant Pathogen Interactions: 2025" Topic in Frontiers in Plant Science.

Our recently launched research, when we investigate the virome of weeds growing in protected natural habitats, fits with the SDG 15 - Life on Land, as the result of this study will answer the question of whether protected species are endangered by the plant viruses which could arrive to this area by spread of the invasive weeds and insect vectors, which emerge because of the changing climate.

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