EDITORIAL

Environmental Engineering and Management for Interdisciplinary Research-based Solutions and Education for Sustainable Transformations

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Environmental sustainability is the foundation for maintaining global systems and supporting economic development within society. However, issues such as the climate crisis, overexploitation of natural resources, biodiversity loss, and significant alterations in ecosystems, complicate our ability to thrive in an ever-changing environment. These issues have far-reaching implications, from personal well-being to the vulnerability of entire populations to food and water scarcity, energy challenges, hazardous substances, and social inequalities. These challenges transcend the boundaries of specific scientific disciplines.

Environmental Engineering plays a pivotal role in advancing technological and engineering innovations aimed at addressing these environmental challenges. Environmental Management adopts a broader perspective, serving as the cornerstone for the systematic analysis of complex systems, with a focus on regulating and regenerating natural, industrial, and regional systems. This includes managing natural resources, materials, and product flows, emphasizing efficiency, reducing negative environmental and health impacts, and promoting the circular economy – a concept oriented towards closed, self-sustaining material systems within the economy.

In response to increasingly stringent environmental regulations, advanced research-based solutions from fields like nanotechnology, biotechnology, materials science are being integrated to develop innovative environmental engineering technologies. However, achieving genuine sustainability requires evaluating not only environmental aspects but also social and economic factors. Analysing complex global challenges from diverse fields is becoming more commonplace in academia, driving changes in environmental engineering research.

Regenerating systems, fostering interdisciplinary collaboration, and promoting strategic sustainable thinking are emerging trends in both research and practice. These trends aim to develop sustainable and viable systems. One such initiative is the interdisciplinary master's programme in Sustainable Management and Production at Kaunas University of Technology (KTU), which focuses on solving complex sustainability challenges through interdisciplinary approaches. This programme has received recognition from international study quality evaluation committees as an excellent example of interdisciplinary education that prepares students to address complex environmental issues. Research-based education serves as the foundation for disseminating research findings and involving students and social partners in the research process.

The significance of environmental and interdisciplinary research is emphasised in global, regional, and national strategies, as well as institutional initiatives. As of 2023, we are halfway through the Global Agenda 2030. While some progress has been made, indicators based on reports from the Intergovernmental Panel on Climate Change (IPCC) and Sustainable Development Goals (SDG) show that substantial efforts are still required, and time is running out. Science plays a crucial role in achieving these goals, as research-based solutions are deemed

reliable and practical. The challenge lies in effectively translating research into practice. The European Union's Green Deal strategy holds promise as an organisational roadmap aligning business and research towards common sustainability objectives.

Regional and global strategies highlight the urgent need for environmentally positive solutions, aligned with social, economic, legal, and collaborative aspects of sustainability. Environmental engineering research and research-based solutions incorporate these aspects to address comprehensive questions, moving beyond fundamental research and emphasising the interplay of various specialists and disciplines. Sustainable thinking becomes a horizontal theme, where insights from different fields can lead to innovative sustainable solutions and the emergence of new research fields, such as green digital transformations.

This evolution changes the role of science and scientists, shifting from merely identifying research gaps to actively developing research to deepen our understanding of key topics. Research and higher education must support society and all stakeholders in the process of sustainable transformation. Achieving this balance and coordination between research and applied activities, leading to innovations based on research and advanced methodologies, is a crucial aspect of contemporary science. Community-based research extends beyond social sciences and has become central in addressing environmental and interdisciplinary research topics. End-users of research results become interactive partners in the research process, often contributing to ongoing knowledge development, further integrating the impact of knowledge into the realm of science and engineering research.

The potential of research to foster sustainable transformation is on the rise. However, transparent processes and results depend on open exchanges of information and data with practitioners. Examples from research collaboration at Kaunas University of Technology, such as the development of the "Roadmap for Lithuania's Industrial Transition to a Circular Economy", highlight the need to engage with a diverse group of users, informal actors, or practitioners who form an ecosystem around research topics. This engagement necessitates employing various research methods, including material flow analysis, life cycle analysis, community-based research, governance and policy research, as well as technological and industrial analysis and solutions. Science, policy, and practices are interconnected and oriented toward a common goal.

Education and raising awareness of sustainability within academic and inter-institutional settings form the foundation for further research integration into practice. The transition to a sustainable, circular, and climate-neutral economy carries significant implications for employment and social well-being. The demand for professionals in climate-neutral and resource-efficient sectors is growing. The Institute of Environmental Engineering, KTU, collaborates closely with international institutions through ERASMUS projects focused on sustainable education and well-being, such as "Sustainable Management – Tools for Tomorrow" (T004T0) and "Sustainable Well-being – Education for Personal, Professional, and Planetary Well-being" (SWEPPP).

Studies focusing on sustainability, green technologies, circular economy principles, and reducing environmental impact are of great importance in Europe and Lithuania. The ability to adapt knowledge and research methods in interdisciplinary teams narrows the gap between science and society, fostering systematic engineering-based thinking for sustainable transformations.