Human-Centric 5.0 platform for participation into ESIA and SEA Processes

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ABSTRACT: Artificial Intelligence is a disruptive technology which will impact the whole participation process into permitting and governance systems at a global and local scale. This human-centric Impact Assessment approach is focused on AI-based collaborative multi-stakeholder platform enhancing environmental and social sustainability through a structured local Hackathon participation framework.
The methodology provides:
1) Site-specific data framework which describes the effective environmental and social problems improving specific KPI values;
2) AI-based Decision Support System for SDG-Objective and Key results planning & stakeholder engagement in a 5.0 “whole of society” approach;
3) Institutional monitoring based adaptive management system to enforce and promote an effective SDG collaborative strategy at a local scale.
The platform enables predictive assessments and adaptive management, equipping stakeholders with real-time data insights. As a pioneering initiative, it actively involves public and private sectors, IA consultants, trade associations, schools and local communities.
This innovative and integrated human centric approach introduces a general methodology and operational framework to improve, evaluate and monitoring Artificial Intelligence applications, correcting its improvements on social and environmental evidence/data into ESIA/SEA/CSR processes

SUMMARY STATEMENT: A general AI framework for an effective Human-centric participation into ESIA and CSR permitting and governance systems

KEY WORDS: **Human-Centric Impact Assessment, AI-based Decision Support System, q-HACK5.0, Evidence-based Policymaking, Predictive assessments, Qcumber platform, School-based observatories.**

Introduction

Artificial Intelligence (AI) is transforming permitting and governance processes worldwide. Adopting a human-centered Impact Assessment approach through concrete instruments—such as a dedicated AI-driven multi-stakeholder platform and a structured local Hackathon—can significantly boost environmental and social sustainability. The methodology includes site-specific socio-environmental data frameworks for identifying and addressing key issues, an AI-based Decision Support System aligned with socio-environmental SDGs (Sayed., 2015) to engage different stakeholders, and an adaptive management system for effective local strategies.

In this context, by delivering real-time insights and AI instruments, the Qcumber platform (Magro et al., 2016) enables predictive assessments and fosters broad collaboration among public and private sectors (Wirtz et al., 2019), consultants, associations, schools, and communities, ensuring that social and environmental benefits are fully integrated into ESIA/SEA/CSR processes (Repubblica Italiana., 2006). It provides a transparent, data-driven system for measuring, assessing, and monitoring environmental impacts and sustainability. As a multi-stakeholder platform supporting urban and regional governance, it offers an objective, verifiable, and replicable way to quantify environmental impacts, while facilitating the design of eco-sustainable solutions through AI , focusing on specific KPI. Continuously updated by an international team of researchers, practitioners, and institutions, it leverages evolving knowledge and advanced technologies to monitor impacts in a predictive, collaborative manner, thereby driving continuous improvement performance of both public and private organizations. Through the q-HACK5.0 initiative (a specialized form of hackathon), youth are empowered to work on local issues, leveraging both real-time data from this platform and their own experiences. In small groups, they develop critical thinking and collaborative problem-solving skills, generating key results planning and stakeholder engagement in a 5.0 "whole of society to share with decision-makers aligning with the UN's 2030 Agenda for Sustainable Development (Weiland et all., 2021). This approach empowers young participants to gain confidence and expertise as active citizens, enabling them to identify shared challenges, propose innovative solutions, and collectively work toward a more sustainable future. Through the platform and hackathon process, students from the participating school can pinpoint environmental issues in their municipalities and, by using AI tools, propose mitigation measures for various Urban Development Plans (UDP) projects as well as address environmental conditions in SEA (Strategic Environmental Assessment) and ESIA (Environmental-Social Impact Assessment) in accordance with Articles 28 and 18 of the Italian Legislative Decree 152/2006.

Materials and Methods

Within the framework of a structured local hackathon, students from a school in the participating municipality are immersed in a carefully designed process that leverages the Qcumber platform's data-driven insights and AI-based features. As they work together in small teams, each group navigates the intricacies of urban and territorial planning, delving into the municipality's UDP to identify pressing ecological or infrastructural concerns. Empowered by the platform's capacity to generate predictive assessments, the students can propose targeted mitigation measures tailored to the specific issues revealed in the local UDP.

Overall, the students guided by a specific procedure of five stages listed below, based on data and information provided by the Qcumber Platform, they work to codify the problem, identify a potential solution and formulate a dedicated Action Plan to share and work on with public institution.

Stage 1

Territorial scope: During this step, participants identify and designate the specific area within the municipality that will be the focus of their efforts, laying the groundwork for the subsequent project implementation.

Stage 2

Problem setting: Recognizing and defining a socio-environmental issue—using site-specific data frameworks and an evidence-based analytical procedure—is essential for effective intervention. In this phase, students establish an objective, counterfactual, and comparative knowledge framework supported by the Qcumber platform. This model codifies the problem, identifies causes and affected parties, and highlights relevant stakeholders. A diagnostic approach clarifies who or what causes the issue and who or what is impacted, helping participants develop targeted, collaborative strategies. The platform provides georeferenced satellite and ground-truth data (Inness et al., 2019) on pollutant and climate-altering emissions, attributed to specific sectors (e.g., road traffic, residential combustion). The platform provides georeferenced satellite and ground-truth data on pollutant and climate-altering emissions, attributed to specific sectors (e.g., road traffic, residential combustion) (Granier et al., 2019). It integrates this information with local vulnerabilities, offering a comprehensive view of current conditions and potential future impacts. Once the baseline condition is established, the platform also enables the geolocation of additional building developments or land transformation initiatives within the same area, along with the mitigation measures proposed as part of these initiatives. The numerical assessment of their impacts can then be carried out in the subsequent problem-solving phase. Issues are visually highlighted with color-coded q-posts (**Figure 1**) - for example green for high quality or red for severe degradation—providing clear and immediate environmental insight.

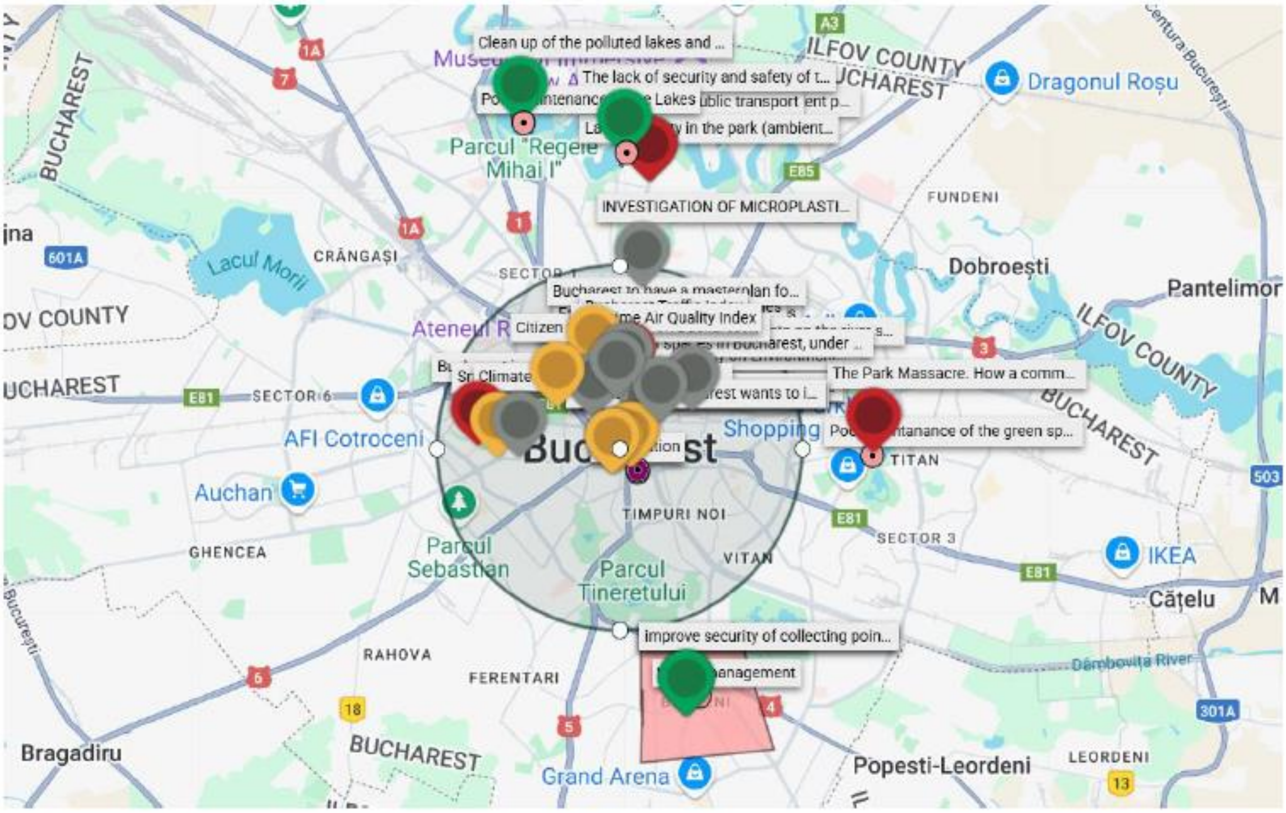

Figure 1: Bucharest area with q-posts on the Qcumber platform. Green Q-posts highlight areas with excellent socio-environmental quality. Red Q-posts indicate areas facing serious degradation. Yellow Q-posts refer to newspaper articles related to the analyzed territorial unit. Grey Q-posts refer to scientific articles concerning the same area.

Stage 3

Problem Solving: Identifying and codifying a problem, together with defining a shared strategy that integrates an AI-based Decision Support System for planning SDG-related Objectives and Key Results, fostering stakeholder engagement within a 5.0 'whole-of-society' approach, and providing the necessary operational tools, are all crucial and interconnected steps toward its resolution. This process requires an Action Plan that outlines how people can contribute—from recognizing the issue to assessing and implementing possible solutions—and should be tested in real-world conditions to measure and refine its effectiveness. Known as “Evidence-based Policymaking,” (Strydom et al., 2010) this data-driven approach, made feasible by the Qcumber platform, offers a significant opportunity for improving the governance of future cities and territories. Specifically, thanks to the platform, students can pinpoint local challenges and estimate the potential impact of proposed solutions by using advanced tools that leverage machine learning–based predictive control, calibrated with counterfactual outcomes (ML–BCA, or Machine Learning Based Corrective Actions). This approach enables them to anticipate and measure the effects of different mitigation strategies, refining their decisions for more effective outcomes. Specifically, the students are equipped with a solid understanding of the territory’s initial conditions, derived from the social and environmental information provided by the platform in the earlier stage of the process. After geolocating building projects or land transformation initiatives within the area under analysis during the problem-setting phase (**as shown in Figure 2**), users are able in this phase to calculate the additional impacts resulting from pollutant and climate-altering gas emissions associated with these same urban interventions. At the same time, they can assess the effectiveness of the proposed mitigation and adaptation measures—such as the CO_2 absorption achieved through strategic tree planting—in clear numerical terms rather than approximations. This provides a systematic and robust evaluation of the proposed solutions.

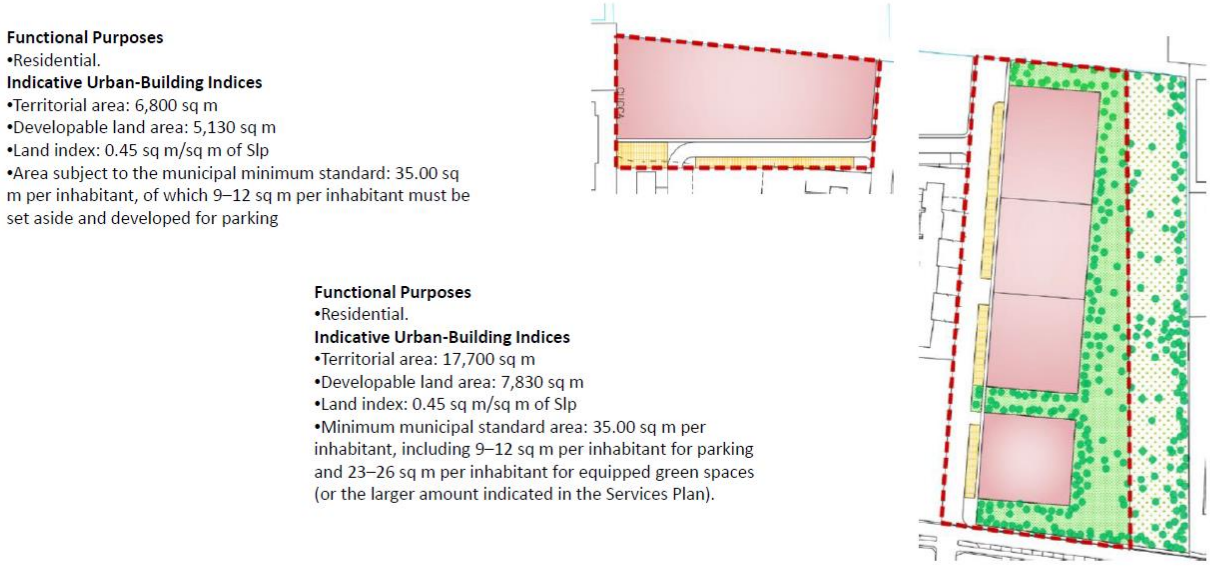

Figure 2: Example of a building development within a municipality area where a mitigation measure involving tree planting is also planned, based on the predicted paved surface area.

Stage 4
Business Model/Action Plan: Building a business model based on the suggested solution begins with a clear definition of the value proposition that addresses the identified challenges (Osterwalder & Pigneur., 2010). This involves outlining the innovative solution and identifying all relevant stakeholders, both directly and indirectly impacted. Equally important is establishing partnerships with organizations and individuals who offer complementary expertise, resources, and networks to support the initiative. Key resources—technological, financial, or human capital—are then mapped to ensure the right assets are in place to drive the project forward. The model also outlines the key activities for successful implementation, from research and development to execution and continuous monitoring. Cultivating strong stakeholder relationships remains central to this approach, with open, ongoing communication through digital platforms, social media, community events, and direct collaborations to ensure effective outreach and engagement.

Stage 5
Project presentation and sharing: Public presentation of the work carried out, the results achieved, and the choices made, as well as the data used to support them. In this phase, the full extent of the work undertaken must be clearly demonstrated. The exemplary and constructive use of Artificial Intelligence serves as a powerful tool for deepening the understanding of the territory and fostering effective collaboration between schools and institutions. This approach is designed to provide students with concrete, measurable solutions based on prior analyses of territorial systems, with the ultimate goal of developing robust systems for predictive measurement, evaluation, and adaptive impact monitoring. This entails a structured monitoring phase, conceived as an annual cyclical process that aligns seamlessly with the standard school curriculum. It is based on predictive data powered by artificial intelligence and focuses on key performance indicators (KPIs). The approach ensures the active involvement of both internal and external stakeholders, enabling the implementation of an adaptive management system grounded in institutional monitoring. This system is designed to strengthen and promote an effective collaborative strategy for the Sustainable Development Goals at the local level, with the school playing an active role as a 5.0 observatory of concrete policy decisions.

Results and Discussion
During the most recent edition of the Q-Hack 5.0, the platform highlighted baseline issues related to the territory's environmental conditions, particularly high levels of air pollution and emissions of climate-altering gases. These impacts were traceable to specific sources, with road transport and residential

combustion consistently emerging as the two main contributors across the analyzed territorial units (an example is shown in **Figure 3**).

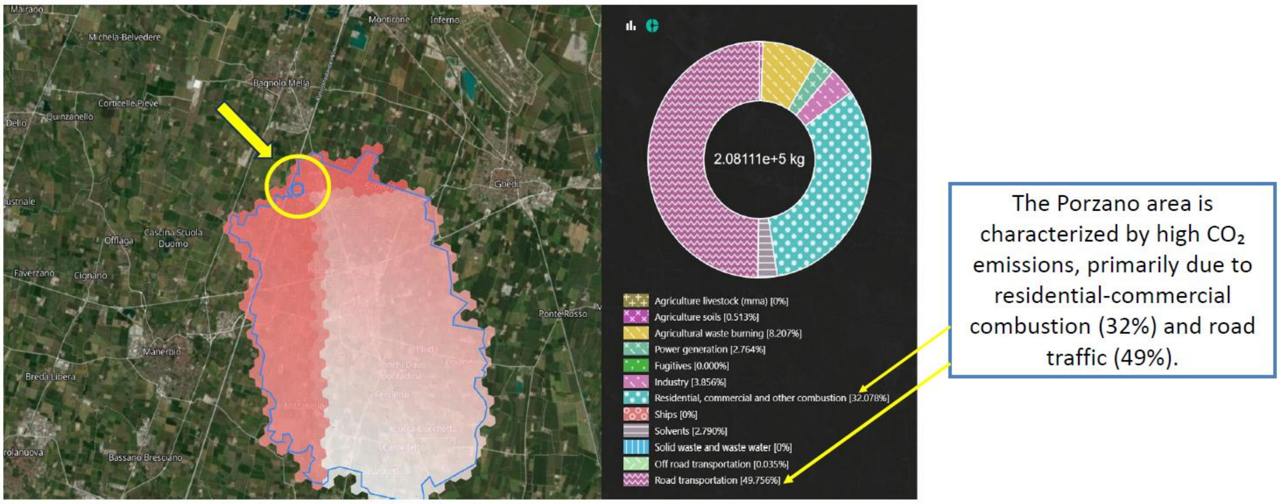

Figure 3: The municipality of Leno is outlined in blue. Each hexagonrepresents the annual CO_2 emissions within that area, originating from various sources. The hexagon selected for the project is highlighted by a yellow arrow and bordered in blue. On the right-hand column, the attribution of these emissions is broken down by sector. In this specific case, 32% and 49% of the CO_2 emissions in the selected cell are attributable to commercial-residential combustion and road traffic, respectively.

Once the baseline conditions were assessed, the analysis frequently moved on to future municipal building developments or land transformation initiatives, in order to estimate their additional impacts in terms of pollutant and greenhouse gas emissions.

Subsequently, the evaluation focused on potential solutions, either proposed by students or already included in municipal plans, which could be quantified using the platform's predictive capabilities. What clearly emerged is that, in many cases, interventions such as tree planting, the adoption of electric vehicles, and the installation of photovoltaic systems can absorb or avoid emitting more tons of CO_2-equivalent than those generated by the electricity consumption of a new residential area (Environmental Protection Agency., 1995; European Environment Agency., 2019). Similar results were observed with measures aimed at increasing and incentivizing public transport or replacing combustion-engine vehicles with electric ones. Here, in **Figure 4** an example of municipal building developments is shown in the hexagon highlighted in **Figure 3**, where the potential annual CO_2 emissions from future residential electricity consumption—estimated at 165 metric tons—are offset by 196 metric tons of CO_2 absorbed through tree planting, along with an avoided emission of 883 metric tons thanks to the installation of a rooftop photovoltaic system.

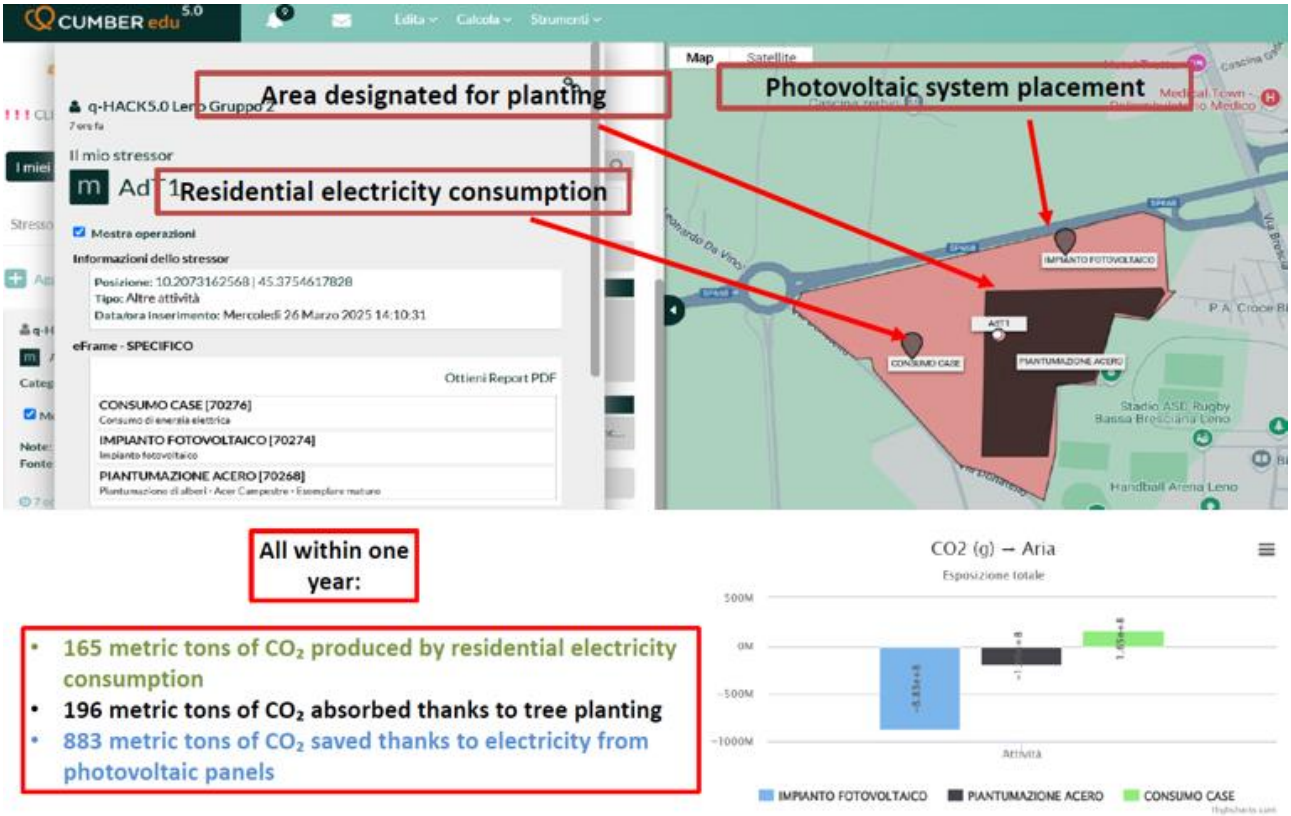

Figure 4: An example of municipal building developments is illustrated in the hexagon highlighted in Figure 3, where the potential CO_2 emissions from future residential electricity consumption (green bar) are fully offset by a combination of CO_2 absorption through tree planting (black bar) and avoided emissions made possible by the installation of a rooftop photovoltaic system (blue bar)

Overall, the most recent edition of the Q-Hack 5.0 successfully engaged over one hundred students coming from five different European countries, working in different and multidisciplinary teams, who successfully developed a total of eleven project proposals (**Fig 5**). Each of these projects addressed pressing local challenges and was grounded in data-driven analysis. The initiative sets the stage for a potential follow-up phase focused on the monitoring of the proposed interventions, which could be carried out in close collaboration with the relevant public institutions and authorities.

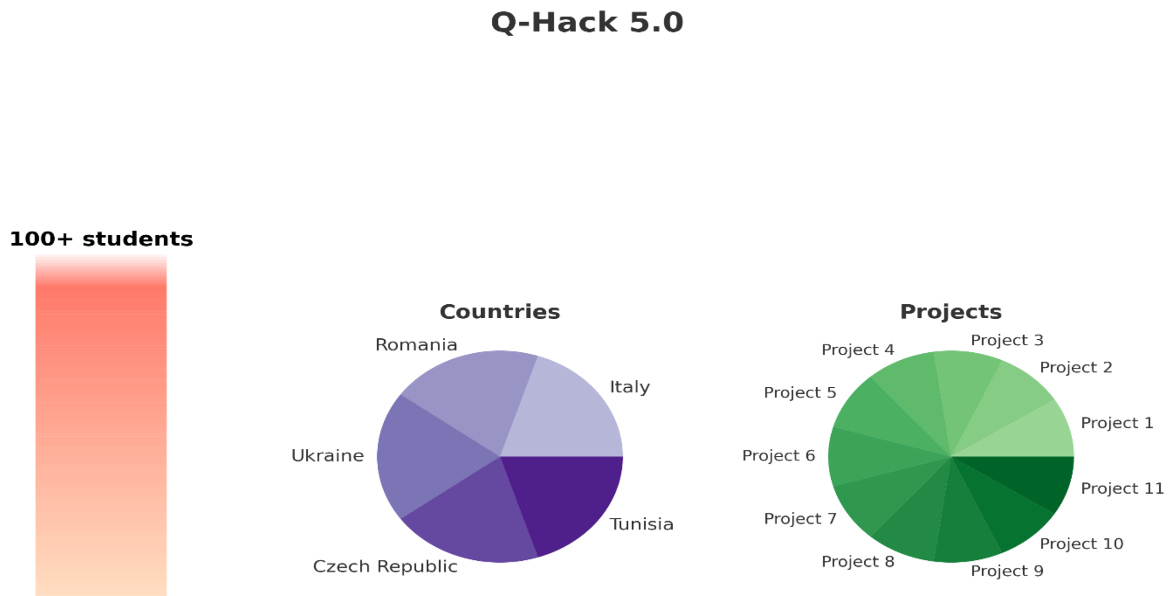

Figure 5: Q-Hack 5.0 event. The number of students involved is shown in a red gradient bar, while the purple pie chart displays both the number and the list of countries from which the students come. Finally, the green pie chart represents the total number of projects developed.

Conclusion

This human-centric impact assessment approach proposed here, combines AI-driven tools and local stakeholder engagement through a structured Hackathon framework to support environmental and social sustainability. The methodology integrates: (1) a site-specific data model to identify and improve key environmental and social KPIs; (2) an AI-based Decision Support System for SDG planning and stakeholder collaboration within a 5.0 "whole-of-society" context. Moreover, the forecasts of potential pollutant emissions and the corresponding countermeasures—whether through absorption or avoided emissions—emerging from the students' calculations enable the development of an adaptive management system for school-institutional monitoring of future municipal plans examined, in synergy with local authorities. This model can be replicated to support school-based monitoring of the evolution of ESIA and SEA processes.

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