ESG 5.0 Human-Centric Permitting Platform

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Abstract: The implementation of Artificial Intelligence (AI) in environmental permitting and "Do No Significant Harm" (DNSH) assessments enables efficient, data-driven decision-making within complex environmental impact evaluations. This approach supports comprehensive assessments by integrating AI-powered data analysis and predictive tools, streamlining traditionally intensive Environmental & Social Impact Assessments (ESIA) and Strategic Environmental Assessments (SEA). The platform incorporates ground truth data and machine learning to evaluate potential environmental impacts, delivering precise, objective metrics essential for regulatory compliance. By enabling a cohesive information framework, stakeholders can access and share critical data, promoting enhanced transparency and accountability in environmental governance. Additionally, the system allows for dynamic monitoring and real-time updates on environmental parameters, with an emphasis on managing cumulative impacts and specific disturbances, such as odor emissions, across various project types. This innovative AI application fosters environmental sustainability by ensuring that mitigation strategies are based on reliable data, thus supporting the primary goal of minimizing ecological harm and aligning with international and EU regulatory standards.

Key words: Platform, ESIA, SEA, DNSH, Permitting, Artificial Intelligence, Machine Learning, Blockchain technologies

Summary Statement: AI enhances environmental permitting and DNSH assessments by streamlining impact evaluations, ensuring data-driven decisions, and fostering sustainability through predictive and real-time monitoring tools

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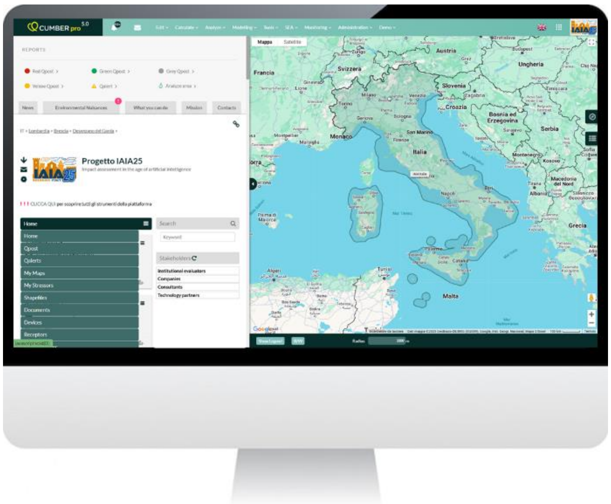
Introduction

The advent of Artificial Intelligence (AI) is transforming environmental governance. Environmental governance in Europe is facing a critical transition. The integration of sustainability into all levels of decision-making — as required by the EU Green Deal, the Taxonomy Regulation (EU 2020/852), and the Corporate Sustainability Reporting Directive (CSRD, Directive 2022/2464/EU) — is creating new demands for transparency, data integration, and adaptive monitoring within environmental permitting systems.

In response to this challenge, the ESG 5.0 platform introduces a human-centric, AI-powered approach to environmental assessment and decision support. Designed as a modular and interoperable system, ESG 5.0 enables institutions and project proponents to collaborate through shared digital workflows, structured data input, and predictive analytics — enhancing the quality, accountability, and timeliness of permitting decisions.

The Permitting Platform 5.0 framework involves the participation of:

1. Institutional evaluators
2. Evaluated companies
3. Consultants
4. Solution providers (suppliers)
5. Scientific/educational/technological enablers



The Permitting Platform 5.0 supports a wide range of use cases, including Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), Integrated Environmental Authorisation (IPPC), and DNSH (Do No Significant Harm) evaluations required for public and private investments and sustainability reporting. It has been successfully implemented in various institutional contexts, including:

- Lombardy Region: EIA screening procedure of waste treatment plants (DGR n. 5223/2021);
- Umbria Region: regional permitting procedures (DGR n. 117/2023);
- Puglia Region: regional permitting procedures (DGR n. 263/2025);
- IZSLER: Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia-Romagna, Environmental Impact Rating of farms;
- Environmental Protection Agency (ARPA) Umbria Region: ESIA and SEA DSS;
- UNICEF Italy: q-City 5.0, youth participation and digital active citizenship;
- Monza and Brianza Province: EIA, SEA integrated assessment, stakeholder engagement and impact credit;
- L'Aquila Province: where it supports the monitoring of the SEA of the Provincial Spatial Coordination Plan (PTCP), enhancing the integration of environmental objectives into territorial planning;
- Municipalities of Brescia Province: where the platform is used for SEA predictive monitoring within the town's General Urban Plan;
- Regional Professional Association of Engineers (Lazio Region): DNSH DSS for Integration of sustainability into the design and planning sector.

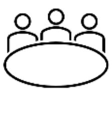
Through these deployments, ESG 5.0 has demonstrated its capacity to combine scientific rigor with institutional usability, enabling an evolutionary model of permitting — one where decisions are not only compliant, but also traceable, participatory, and performance-driven.

Materials and Methods

The methodology

The implementation of the Permitting Platform 5.0 in a territorial unit utilizes a methodology based on systems engineering applied to territorial systems, whit the following steps:

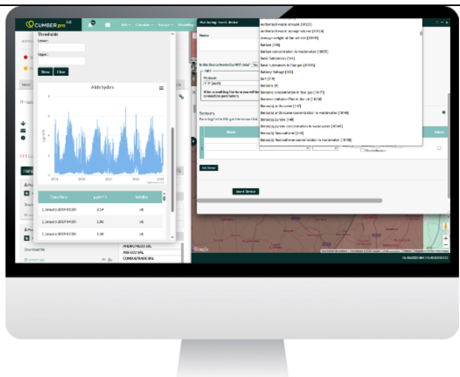
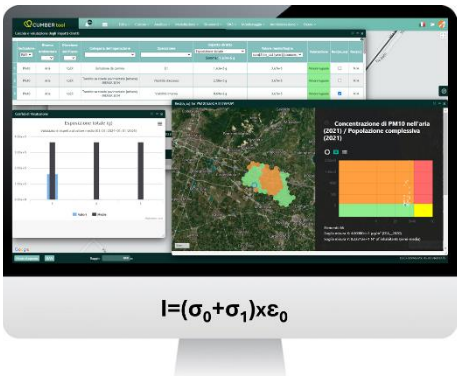
<table>
<tr><th colspan="2">Phase</th><th>Phase description</th><th>Output</th></tr>
<tr><td>A1</td><td></td><td>Methodological sharing of the Permitting 5.0 model. This phase involves proactively engaging institutional stakeholders, including Ministry of the Environment, Regions, Provinces, Municipalities, ARPA, and ASL, to foster the construction of the multi-stakeholder network.</td><td>Methodological Implementation Document for the Permitting Platform 5.0</td></tr>
<tr><td>A2</td><td></td><td>DCGIS® methodology for Impact Assessment evaluation:
1. Definition of the reference spatial domain (R).
2. Definition of the reference time domain (T).
3. Identification of the elements of the system (pressure and vulnerability elements: $\boldsymbol{E = E_\sigma, E_\varepsilon}$):
a. Characterization of the project/plant (σ_1): conceptual model through the georeferenced characterization of the main operations carried out (OP_j, e.g. water discharge points, atmospheric emissions, etc.).
b. Characterization of the reference territorial-environmental context: elements of environmental vulnerability (ε_0 - biodiversity, human communities, landscape, soil, water, air...) and territorial stressors (σ_0 – infrastructures, industrial plants, quarries, landfills, farms...) present in the surrounding territory within a radius of at least 1500 m.
4. Identification of element $\boldsymbol{e = u_j, v_k}$attributes (pressure and vulnerability attributes).
To define the attributes, predictive/statistical data, nominal data (authorisation maximums) and real data (deriving from monitoring carried out/management data) can be used.
5. Definition of the Relationships between elements/attributes (E x E, uj x uj , E x u):
a. Measurement and evaluation of specific direct impacts on environmental resources (ER)
$$I(\sigma_1) = Z^{ER}_{\sigma_1} = Z^{ER}_{m_1}$$
b. Measurement and evaluation of cumulative direct impacts on environmental resources (ER)</td><td>Integrated report for the analysis and assessment of the enterprise's specific and cumulative direct and indirect potential impacts</td></tr>
</table>

Phase		Phase description	Output
		$$I(\sigma_0) = Z^{ER}_{\sigma_0} = Z^{ER}_{\overline{m_1}}$$ The calculation of impacts (typically annual) is based on standard emission factors and benchmarks (e.g. EEA). For cumulative impacts, the platform compares the plant's emission load with that of other environmental stressors present within 1500 m. c. Measurement and evaluation of **specific indirect impacts**; $$I(\sigma_1) = Z^{HC,ES}_{\sigma_1} = Z^{EC,ES}_{m_1}$$ d. Measuring and evaluating **cumulative indirect impacts** . $$\boldsymbol{I(\sigma_0) = Z^{HC,ES}_{\sigma_0} = Z^{HC,ES}_{\overline{m_1}}}$$ To assess indirect impacts on human communities (HC) and ecosystems (ES), the platform uses fallout models based on management and context data, allowing the calculation of emissions on sensitive receptors and the generation of analytical reports. 6. Construction of the analytical database containing the **detected states (a_i)**, starting from which it is possible to carry out: a. Analysis of the trend of the collected data (univariate analysis, bivariate analysis, multivariate analysis); b. Evaluation against attention thresholds/benchmarks; c. Diagnostics (Machine Learning). 7. Identifying any issues encountered in the domain of the selected relationships. 8. The identification and evaluation of the impact components of the Improvement Actions (A) on any problems identified $$A = q - [\sigma_1(\varepsilon_0 + \varepsilon_1) + \sigma_0(\varepsilon_0 + \varepsilon_1)]$$	
A3		Planning of strategic/operational improvement objectives and related key actions through specific Impact Performance Improvement Plans, broken down into objectives and key results/indicators (OKR Plans) which include, for example, impact mitigation/compensation measures, defined in a measurable and site-specific manner, which can be monitored over time in an adaptive manner	Key actions to improve environmental impact performance (including environmental conditions: mitigation and compensation measures)

Phase		Phase description	Output
A4		Execution of the actions foreseen by the OKR Plan (Blockchain stack implementation)	Sustainability OKR Plan
A5		Operational management of the dynamic measurement and preventive/predictive monitoring system (MLBCA): Monitoring the impact of actions, assessing the impact of actions and identifying corrective actions based on machine learning and predictive control calibrated with counterfactual outcomes (MLBCA – Machine Learning Based Corrective Actions).	Scheduled monitoring reports

Architecture and Functional Modules

The Permitting Platform 5.0 is composed of several integrated modules:

ETL / Data Entry Module: for structured collection of environmental, territorial, and project-specific data.	
AI4EIA / Assessment Module: utilizes machine learning and ground truth data to calculate environmental impacts, both direct and cumulative.	

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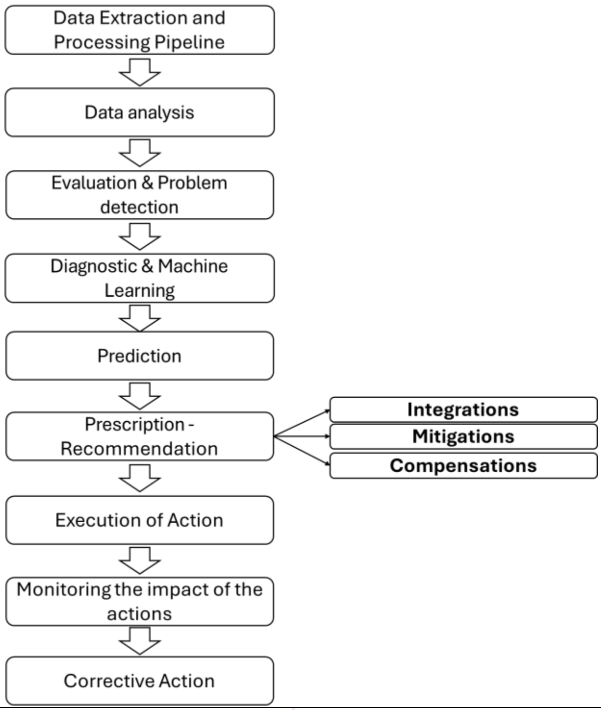
<td>Predictive Recommendation Engine: AI models simulate impact trajectories and generate site-specific recommendations for mitigation, compensation, and redesign. The system provides a validated and selected Impact Assessment standard model suite to measure and calculate effective Environmental Performances and an integrate Monitoring Based Corrective Actions system to manage and improve the environmental performances.</td>
<td>
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<td>Visualization Module: Automatic reporting modules, tailored to both institutional stakeholders and private proponents, produce outputs for internal use and public disclosure.</td>
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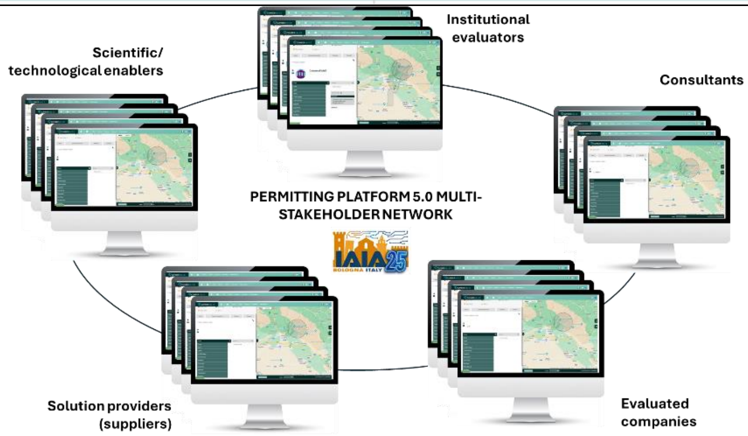
<td>Multi-Stakeholder Network: facilitates shared governance, transparency, and co-creation between institutions, proponents, and civil society.</td>
<td>
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These tools aim to enable transparent, accountable, and reproducible decision-making processes across all levels of governance.

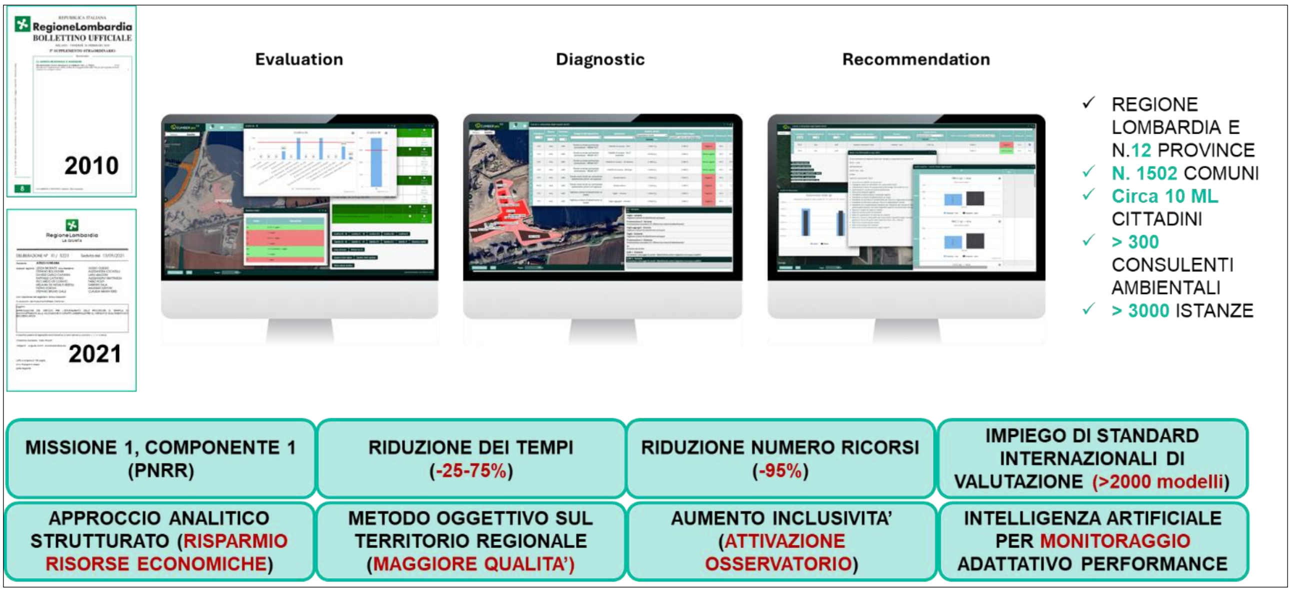
Results and Discussion

Case Study 1: Lombardia Region

The Regional Decree XI/5223 establishes an updated and standardized methodology for the screening of waste management plants to determine whether they should undergo Environmental Impact Assessment (EIA), in compliance with the latest EU and national legislative updates (Directive 2014/52/EU, Legislative Decree 104/2017, etc.).

The method is based on a structured and science-based system to support decision-making by competent authorities. It is designed to evaluate both specific and cumulative environmental impacts, considering site-specific vulnerabilities and environmental stressors within the affected area. The approach relies on:

- Four main evaluation functions (impact indices IA, IB, IC, ID, IE1, IE2, IF, IG), addressing specific, cumulative, and indirect impacts;
- A geospatial information system with structured data layers (including biodiversity, air/water quality, population density, and existing facilities);
- The use of benchmarks and thresholds to guide significance determinations;
- The creation of an online application tool to standardize and accelerate evaluations, available both to authorities and project proponents.

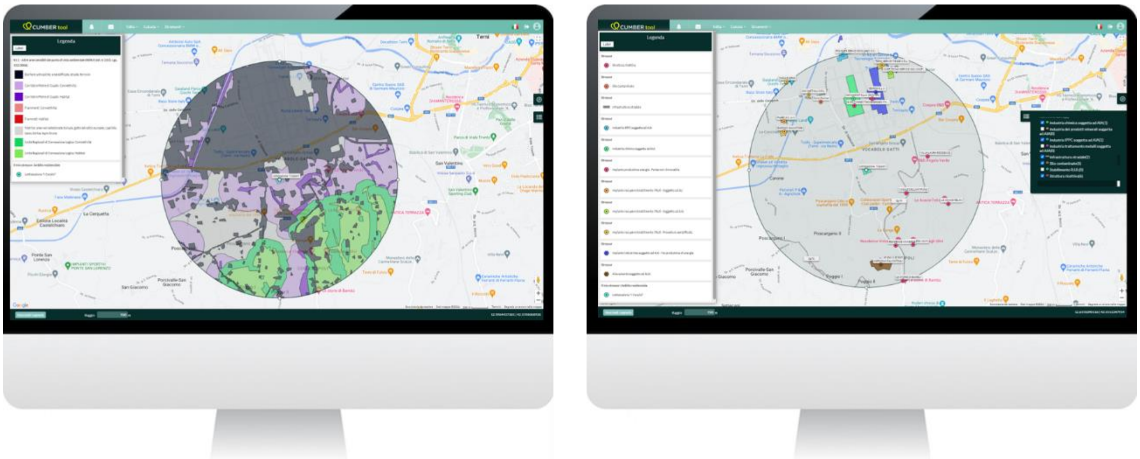


Case Study 2: Umbria Region

The environmental permitting initiative launched under Regional Resolution no. 117/2023 by the Umbria Region aimed to strengthen the institutional capacity for Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), and Integrated Environmental Authorization (IPPC) through a unified, science-based digital platform. The project's core objective was to define and operationalize a shared, site-specific baseline information framework capable of supporting consistent, high-quality impact evaluations across regional and local contexts.

To achieve this, the platform was designed to standardize the characterization of territorial contexts by codifying both anthropogenic pressures and environmental sensitivities. Specifically, the first step of the project was to implement a geospatial information system integrating **34 categories of stressors** (e.g., industrial facilities, waste treatment plants, livestock operations, linear infrastructure, and pollution sources) and **45 types of vulnerability and sensitivity layers** (including Natura 2000 sites, aquifer protection areas, air and water quality zones, seismic and hydrogeological risk areas, and cultural and landscape heritage zones). This framework supports automated pre-assessment and predictive modelling, enabling a more objective and transparent identification of potential environmental impacts, as well as the definition of suitable mitigation strategies.

Stressors and vulnerability



By ensuring open access to standardized environmental data and facilitating collaborative workflows between proponents and authorities, the platform promotes both regulatory compliance and environmental performance. It also allows early identification of critical conditions, reducing delays in permitting and improving the effectiveness of monitoring and adaptive management throughout the project lifecycle.

Conclusion

The Permitting Platform 5.0 demonstrates how Artificial Intelligence and Blockchain technologies, when designed around human and environmental needs, can transform environmental permitting into a predictive, participatory, and accountable systems. Grounded in operational practice, this model offers a roadmap for other municipalities and institutions looking to navigate the complexities of green regulation and sustainable development, integrating permitting and procurement into an institutional integrated impact credit multi-stakeholder governance Platform.