European Union Network for the Implementation and Enforcement of Environmental Law

Geospatial Intelligence for Environmental Damage Assessment

Final Report

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the European Union (EU) Member States, and of other European authorities, namely from acceding and candidate countries of the EU and European Economic Area (EEA). The association is registered in Belgium and its legal seat is in Brussels, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 8th Environment Action Programme that guide European environmental policy until 2030, the EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil" on Flagship 5 and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation.

Information on the IMPEL Network is also available through its website at: www.impel.eu

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Project Manager: Federico Filipponi (IT) **Authors:** Federico Filipponi (IT), Laura Calcagni (IT), Fernando Gomes (PT), Eva Lima (PT), Vito Sacchetti (IT), Dario Bellingeri (IT), András Attila Takács (HU), Emiliano Agrillo (IT)	**Report adopted at IMPEL General Assembly Meeting**: Adopted by written procedure on 20/03/2025 **Total number of pages: 112** Report: 86 Annexes: 26

Executive Summary

The Geospatial Intelligence for Environmental Damage Assessment (GIEDA) project aims to contribute on information needs related to illegal activities affecting the environmental matrices, demonstrating the capacity in producing ex post evidence of environmental damage caused by environmental incidents, violations, eco-criminal acts. The use of the geospatial intelligence, based on the synergistic use of Earth observation and geostatistical analysis, aims to improve the ability to produce evidence, as an effective methodological approach to support the assessment of environmental damage, in order to be used in court.

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1. The GIEDA project

1.1. Introduction

Rapid growing of geospatial techniques, like spatial statistics and Earth observation technology, as well as recent advances in artificial intelligence, increased the ability in monitoring environmental processes. In the last decades, there has been a growing awareness that geospatial technology has the ability to monitor, inspect and assess the environment, producing the information needed by regulatory practitioners, supporting the investigation of eco-criminal acts and environmental laws infringement. However, competent authorities across EU need to find out what methodological approach best meet the requirements for the investigation of specific eco-criminal acts in the most efficient way.
Here comes the need to increase environmental agencies and regulators capability in the use of geospatial intelligence. Actions that would significantly promote the use of geospatial intelligence to investigate and ascertain eco-criminal acts across EU are:

- identify effective methodological approaches;
- raise the awareness of prosecutors and judges about appropriate and reliable product available from geospatial intelligence;
- perform requirements analysis to identify necessary information for use in the courts that can be generated by geospatial intelligence;
- train environmental agency and competent authorities in the use such analysis techniques.

1.2. Project background

Detecting, investigating, ascertaining and prosecuting environmental violations require high-quality documentation and evidence. New technologies and methods to detect and analyse environmental changes, like geospatial intelligence, can greatly strengthen the monitoring and inspection capacity other than support the assessment of environmental damage by providing qualitative and quantitative information. Synergic use of information collected from various repositories, acquired during in-situ surveys, or acquired by very-high spatial resolution sensors onboard satellites or drones, allows for more detailed assessment of environmental damage. The exploitation of remote sensing time series acquired by satellites with high revisit period, allows to monitor and track anomalies and changes in land cover and to characterize the environmental conditions prior to the damage event.
Previous IMPEL projects already focused on cutting edge developments in the use of technology (e.g. artificial intelligence, Earth observation, Unmanned Aerial Vehicles), by organizing mini-conferences to share knowledge with IMPEL practitioners. Principles of water, land and atmosphere monitoring using Earth observation data from satellite acquisitions, including those collected within the Copernicus EU Programme, is a topic that has been introduced by previous IMPEL projects. Environmental applications of Unmanned Aerial Vehicles in environmental inspections have been also presented by previous “Use of technology in regulation” IMPEL project. In turn, the "Climate Emergency Umbrella Programme" addresses climate emergency issues by designing tools and approaches that regulators can use to tackle the related emerging challenges. The use of geospatial intelligence is also one of the considered approaches.
Other initiatives, like the Copernicus FPCUP project GEOINT4ENV – “Geospatial Intelligence for Environment Protection Against Illegal Activities”, aimed at addressing the needs and demands of users in the subject of geospatial intelligence, with a specific focus on the environmental violations.

1.3. Project scope and objectives

The GIEDA project aims to contribute on information needs related to illegal activities affecting the environmental matrices by reporting effective methodological approaches that use geospatial intelligence, based on the use of Earth observation and geostatistical analysis. Presented good practices contribute to share knowledge, in addition to initialize the process of building technical and procedural capacity in producing ex post evidence of environmental damage caused by environmental incidents, violations, eco-criminal acts. From a practical perspective, the GIEDA project focuses on how geospatial intelligence can contribute to the assessment of environmental damage. The project approach is based on the identification and reporting of real cases (i.e. precedents), which are previous court sentences or administrative procedures, using geospatial intelligence for the general assessment of the case, to identify proofs of environmental damage, for support in environmental damage remediation planning.

The project is one component of an extensive process, which has the wider objective to promote the use of geospatial intelligence to investigate and ascertain eco-criminal acts across EU, to be developed through the continuation of the project initiative in the following phases. Activities to reach this objective are the identification of effective methodological approaches, the requirement analysis to identify appropriate and reliable geospatial intelligence information for use in the courts, and the development of tools and guidelines to train environmental inspectors.

1.4. Geospatial intelligence: overview and definitions

Geospatial intelligence (GEOINT) is intelligence about the human activity on Earth derived from the exploitation and analysis of imagery, signals, or signatures with geospatial information. It describes, assesses, and visually depicts physical features and geographically referenced activities on the Earth. In the European context, the EU Satellite Centre[1] supports the decision making and actions of the European Union in the field of Common Foreign and Security Policy, in particular Common Security and Defence Policy, including European Union crisis management missions and operations, by providing products and services resulting from the exploitation of relevant space assets and collateral data, including satellite imagery and aerial imagery, and related services.

Geospatial intelligence has been developed for public policy purposes geospatial sciences, and it is based on geospatial technologies to achieve a decision advantage. Achieving a decision advantage may result in or require information, that consists of imagery, collected through the Earth observation, geospatial information and geostatistical analysis.

Earth observation is the process of gathering information about the Earth surface, waters and atmosphere through sensors mounted on ground-based, airborne and/or satellite remote sensing platforms. Remote sensing is thus the acquiring of information from a distance. The acquired data are processed and analysed to extract different types of information that can be used to monitor and characterize the status and assess the changes in both the natural and human-made environments, supporting a wide range of applications. Among other initiatives the Copernicus Programme, the Earth observation component of the EU space

[1] https://www.satcen.europa.eu

programme, makes use of a combination of satellites, in-situ sensors and air- and sea-borne sensors to provides data and information that benefits all European citizens.
Remotely sensed data refers to information collected from a distance using sensors such onboard drones, aircrafts, or satellites. The most common remote sensing data used in geospatial intelligence are those acquired from array-type sensors that return two-dimensional arrays of raster (i.e. images).
An unmanned aircraft system (UAS) is an unmanned aircraft and the equipment necessary for the safe and efficient operation of that aircraft. An unmanned aerial vehicle (UAV), a component of UAS generally referred as drone, is defined as a powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, and can carry payloads.
In the framework of Geographic Information System (GIS), the term "image" encompasses wider array of raster datasets that portray any visual representation that is captured by a camera, drone, satellite, or sensor. Diversely, "imagery" pertains specifically to data collected by sensors through remote sensing encompassing not only the individual image file but also its associated metadata, processing, and analysis.
Aerial photographs acquired by aerial vehicle, either airplane, helicopter or UAS, can be used to generate aerial photography mosaics and orthomosaics through a photogrammetry software. An orthomosaic map is a highly accurate, geometrically corrected aerial photography mosaic that provides a true top-down (nadir) view of an area. It is a composite image created by stitching together multiple overlapping orthophotos. Precise positioning is crucial for generating accurate and high-quality orthomosaics in aerial or drone photogrammetry. Photogrammetry is the process of capturing two dimensional images and stitching them together to create a digital model of the physical world by approximating a three-dimensional structure.

1.5. Terminology

Term (alphabetical order)	**Definition**
Environmental damage	Article 2(1) of the Environmental Liability Directive provides that “environmental damage” means: *(a) damage to protected species and natural habitats, which is any damage that has significant adverse effects on reaching or maintaining the favorable conservation status of such habitats or species. The significance of such effects is to be assessed with reference to the baseline condition, taking account of the criteria set out in Annex I;* *Damage to protected species and natural habitats does not include previously identified adverse effects which result from an act by an operator which was expressly authorized by the relevant authorities in accordance with provisions implementing Article 6(3) and (4) or Article 16 of Directive 92/43/EEC ”on the conservation of natural habitats and of wild fauna and flora” or Article 9 of Directive 79/409/EEC*

	"on the conservation of wild birds" or, in the case of habitats and species not covered by Community law, in accordance with equivalent provisions of national law on nature conservation. *(b) water damage, which is any damage that significantly adversely affects:* *(i) the ecological, chemical or quantitative status or the ecological potential, as defined in Directive 2000/60/EC, of the waters concerned, with the exception of adverse effects where Article 4(7) of that Directive applies; or* *(ii) the environmental status of the marine waters concerned, as defined in Directive 2008/56/EC, in so far as particular aspects of the environmental status of the marine environment are not already addressed through Directive 2000/60/EC establishing a framework for Community action in the field of water policy.* *(c) land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms.* Refer to EU COM Notice as regards all aspects of the definition of "environmental damage".
ELD case and non-ELD case	Environmental Liability Directive (ELD) case is a case where the environmental damage or imminent threat is found significant considering the requirements of the ELD. Non-ELD case is a case where the environmental damage under ELD has not occurred or not found.
Remediation	Article 2(11) of the Environmental Liability Directive provides that: *remediation or "remedial measures" means any action, or combination of actions, including mitigating or interim measures to restore, rehabilitate or replace damaged natural resources and/or impaired services, or to provide an equivalent alternative to those resources or services as foreseen in Annex II.*

1.6. Acronyms

ARPA	Regional Environmental Protection Agency
EC	European Commission
ELD	Environmental Liability Directive
ENPE	European Network of Prosecutors for the Environment
EU	European Union
EUFJE	European Union Forum of Judges for the Environment
FCover	Fraction of green vegetation Cover
FPCUP	Framework Partnership agreement on Copernicus User Uptake
GIS	Geographic Information System
HOI	Herman Otto Institute Nonprofit Ltd
IGAMAOT	The General Inspection of Agriculture, Sea, Environment and Spatial Planning
ISPRA	National Italian Institute for the Environmental Protection and Research
GEOINT	Geospatial Intelligence
GIS	Geographic Information System
GPS	Global Positioning System
LAI	Leaf Area Index
NDVI	Normalized Difference Vegetation Index
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle

2. Project methodology

To identify the basic requirements for the application of geospatial intelligence techniques in the context of environmental damage, the adopted approach consisted in the identification of environmental damage cases where the use of such techniques was documented. Cases are included in a broad range of applications: the general assessment of the case, the identification of proofs of environmental damage, and the planning of measures for repairing the environmental damage. The analysis of real cases was deemed essential not only for identifying the requirements for applying geospatial intelligence techniques but also for understanding the limitations of using these techniques.

In order to identify the cases where geospatial intelligence technology has been used to support the environmental damage assessment process, the project followed two principal phases:

1. identification of official databases of environmental damage sentences and public institutions involved in the environmental damage procedures (see paragraph 2.1);
2. collection of the cases of environmental damage where geospatial intelligence technology was used (see paragraph 2.2).

The first phase was realized through a short questionnaire-based survey, disseminated to the national competent authorities for the environmental damage.

The second phase was realized through the following actions:

- query of the identified official databases;
- analysis of EU reports;
- extended questionnaire-based survey addressed to the various parties involved in the environmental damage assessment process (e.g. investigators, environmental agencies, prosecutors).

The methodology adopted to perform these different actions is described in details in the next sections.

2.1. Databases identification

To identifying the available official databases related to cases of environmental damage, an initial survey was done by project member and followers to identify national competent authorities, agencies for environmental damage ascertainment and agencies for environmental damage assessment in the various European countries. This recognition allowed to identify an initial target audience for the questionnaires. Additionally, in order to effectively query the databases correctly, a list of national and local normative references was collected.

Short questionnaire was setup (Annex I) and distributed to the competent authorities for environmental damage by the project members, with the aim of identifying the available official databases related to cases of environmental damage. Other databases at national and European level were identified.

2.2. Cases Collection

Real cases related to the use of geospatial intelligence techniques were collected using various approaches, described in this chapter. Once identified real cases, a set of cases corresponding to events with adequate and complete information were reported.

2.2.1. Database query

Databases were queried using a set of keywords (Annex II), identified to find sentences where geospatial intelligence techniques were used. Once the list of keywords to be used was identified, they were translated into the language of the target databases to be queried.

The use of the keywords to query the databases is optimized on the basis of the specific characteristics of identified databases.

In the Italian context, a combination of keywords was used to achieve a balance between using keywords that are too specific, which might filter out too much data, and keywords that are too general, which would return a very large number of records that were difficult to analyse. Specifically, databases query was conducted using a combination of multiple keywords (as shown in Figure 1), related to three different levels:

- environmental damage (including related regulations);
- type of event;
- geospatial intelligence techniques.

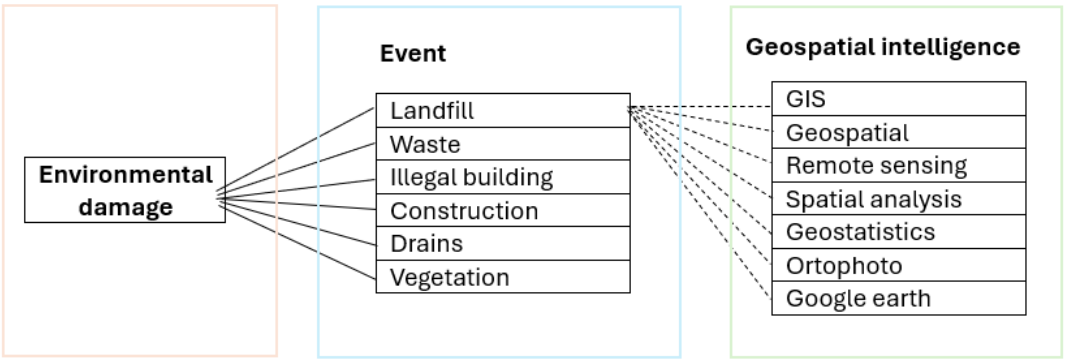

Figure 1. Database query approach

2.2.2. Extended questionnaire-based survey

An extended questionnaire (Annex III) was disseminated to European prosecutors (ENPE network), judges (EUFJE network), national competent authorities, and other national entities involved in the assessment of environmental violations (like for example environmental agencies, investigators, protected area managers) to identify real cases of environmental legal judgments in which geospatial intelligence approaches have been used to detect new potential cases of environmental infringements, support the

assessment and ascertainment of environmental damage, or produce evidence later used in the judgments.

The extended questionnaire is composed of 4 main sections, organized as follows:

- Section A: general information of the responder
- Section B: environmental damage cases reporting
- Section C: other environmental violations cases reporting
- Section D: perspectives of geospatial intelligence

3. Questionnaire-based survey results

3.1. Identification of the official databases of the environmental damage cases

The first phase of the project aimed to identify public institution involved in the environmental damage procedures and the databases of environmental damage cases through a short questionnaire-based survey to national competent authorities for the environmental damage.

The short questionnaire allowed to identify, as reported in Table 1, the public institutions involved in the environmental damage procedures in the various European countries, as well as national and local normative references related to ELD. The list is not to be considered exhaustive for all European countries.

Table 1. Identified entities, national and local regulations

COUNTRY	NATIONAL COMPETENT AUTORITHY	AGENCIES FOR ENVIRONMENTAL DAMAGE ASCERTAINMENT	AGENCIES FOR ENVIRONMENTAL DAMAGE ASSESSMENT	NATIONAL AND LOCAL REGULATIONS REFERRING TO ELD
Albania	Ministry of Tourism and Environment (MTM)	The National Inspectorate for the Protection of the Territory (NIPT) National Environmental Agency (NEA Emvironmental Rajonal Agency Municipality, Department of Agriculture, Forestry and Environment, Inter-institutional Maritime Operational Centre (IMOC)	Some institutions depending on environmental damage by momental order of the minister- National Environmental Agency (NEA) Emvironmental Rajonal Agency Municipality National Forest Agency National Agency of natural Resources National Water Resources Management Authority National Territorial Planning Agency – NTPA	• LAW, No. 10433, dated 16.6.2011 for the Inspection in the Republic of Albania • LAWNo. 10 431, dated 9.6.2011 For Environmental Protection and relevant act depending on this LAW
Italy	Ministry of Environment	SNPA (ISPRA + Agencies for environmental protection) SNPA (ISPRA + Agencies for environmental protection)	SNPA (ISPRA + Agencies for environmental protection) SNPA (ISPRA + Agencies for environmental protection)	• D.lgs. 152/2006
Latvia	Ministry of Environmental Protection and Regional Development of the Republic of	State Environmental Service (SES)	State Environmental Service (SES)	• Latvian Government, Cabinet Regulation No. 281 regarding Preventative and Rehabilitation • Measures and the Procedures for Evaluation of Environmental Damage and Calculation of

	Latvia			Costs of Preventative, Emergency and Rehabilitation Measures, 2007
Slovakia	Ministry of Environment	SEI (Slovak Environmental Inspectorate) District Offices (DO)	District Offices (DO)	• Zákon č. 359/2007 Z.z. o prevencii a náprave environmentálnych škôd a o zmene a doplnení niektorých zákonov (National regulation No. 359/2007)
Portugal (Mainland and Azores and Madeira Autonomous Regions)	Ministry of the Environment and Climate Action	IGAMAOT - General Inspectorate for the Agriculture, Sea, Environment and Spatial Planning	IGAMAOT - General Inspectorate for the Agriculture, Sea, Environment and Spatial Planning	• Portuguese Penal Code on Environmental Crime (Decree-Law n. 48/95), police body with specific competence for investigating environmental crimes. • Enforcement of Environmental Liability (Decree-Law n. º 147/2008)
		APA - Portuguese Environmental Agency	APA - Portuguese Environmental Agency	• Environmental Liability (Decree-Law n. º 147/2008), competent authority • Decree-Law n. º 39/2018 (air emissions) • Law n. 58/2005 (water law) • Decree-Law n. 226-A/2007 (water resources) • Decree-Law n. 151-B/2013 (environmental impact assessment) • Decree-Law n. º 102-D/2020 (waste management)
		ICNF - Institute for Nature Conservation and Forests	ICNF - Institute for Nature Conservation and Forests	• Decree-Law n. º 142/2008 (nature conservation and biodiversity)
		CCDR - Regional Coordination and Development Commissions	CCDR - Regional Coordination and Development Commissions	• Decree-Law n. º 151-B/2013 (environmental impact assessment)
	Ministry of National Defence	National Maritime Authority	National Maritime Authority	• RCM n. 25/93 (clean sea plan) Expertise in marine pollution
	Public Prosecution Service of Portugal		Central Department of State Litigation and Collective and Diffuse Interests	• Prosecution of offences under Portuguese Penal Code on Environmental Crime (Decree-Law n. º 48/95) and Environmental Liability (Decree-Law n. º 147/2008)
	Regional Secretariat for the Environment and Climate Changes (Azores Regional Government)	Environmental Inspectorate of the Azores	Environmental Inspectorate of the Azores	• Regional Legislative Decree n. 30/2010/A (environmental impact assessment) • Regional Legislative Decree n. 29/2011/A (waste management) • Regional Legislative Decree n. 15/2012/A (nature conservation
		Regional Directorate for the Environment and Climate Changes	Regional Directorate for the Environment and Climate Changes	

				and biodiversity) • Regional Legislative Decree n. 32/2012/A (air emissions)
	County District Prosecutors' Office of Azores			• Prosecution of offences under Portuguese Penal Code on Environmental Crime (Decree-Law n. º 48/95) and Environmental Liability (Decree-Law n. º 147/2008)
	Secretariat for Environment, Natural Resources and Climate Changes (Madeira Regional Government)	Regional Directorate for the Environment and Climate Changes	Regional Directorate for the Environment and Climate Changes	• Order n. 1450/2007 (water resources) • Regional Legislative Decree n. 25/2017/M (water resources)
	County District Prosecutors' Office of Madeira			• Prosecution of offences under Portuguese Penal Code on Environmental Crime (Decree-Law n. º 48/95) and Environmental Liability (Decree-Law n. º 147/2008)

The short questionnaire allowed to identify a set of databases containing judgments referring to environmental violations. Nevertheless, it was not possible to identify specific official databases related to environmental damage cases. This issue should be considered partial, since not all the competent authorities in the different countries targeted for the survey answered to the short survey.

3.2. Databases query results – General overview

Considering that no official databases specifically related to environmental damage cases were identified, other identified databases were examined for Portugal and Italy.

In the Portuguese context, despite there being no specific databases related to environmental damage cases, a generic legal database of court appeal sentences[2] was used. The database searches used the approach illustrated in the figure above, namely predefined keywords related to events (e.g. illegal building, drains, waste) and geospatial intelligence terms (ortophoto, Google Earth, GIS). Around 300 court sentences were identified in the legal database containing references to the set of keywords. However, none of these court sentences used information produced by geospatial intelligence as evidence in environmental damage cases.

[2] https://www.dgsi.pt

In the Italian context the recognition of cases was implemented following the approach shown in Figure 1. The analysis investigated in particular Lexambiente[3], a legal journal focused on environmental criminal law that offers a search engine useful for querying its archive using user-selected keywords. The analysis conducted did not allow for the identification of specific cases of environmental damage where the use of geospatial intelligence techniques was documented. In general, the sentences can be very complex and difficult to read for people who are not legal practitioners, and they do not contain detailed information regarding the technical methodologies behind the identification of the evidence that led to the judgment. Although not specifically related to the context of environmental damage, some sentences were found that include observations regarding the use of orthomosaics from Google Earth as a source of evidence. In particular, one sentence related to a building violation[4] is underlined the evidentiary value of the images from Google Earth and Google Street View, considered evidence of their compliance to the places. In a sentence related to a quarry[5], it was noted that the use of orthomosaics from Google Earth is considered acceptable as it is supported by visual and photographic surveys conducted at the site of interest by public officials, as well as by orthomosaics available in public databases.

3.3. Analysis of EU reports

ELD report were examined, in particular the document "Report from the Commission to the European Parliament and to the Council pursuant to Article 18(2) of Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage"[6] and just for Italy the national country fiche "Implementation of the Environmental Liability Directive – Italy – Country fiche 2019" was analysed[7].In these documents, it was not possible to extract information regarding the techniques adopted for the analysis of environmental damage cases; therefore, they are not suitable for the project purpose of examining the potential use of geospatial intelligence techniques to support environmental damage assessments.

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[3] https://www.lexambiente.it

[4] Consiglio di Stato Sez. VI n. 4890 del 31 maggio 2024 from Lexambiente (https://www.lexambiente.it/index.php/materie/urbanistica/consiglio-di-stato64/urbanistica-valutazione-unitaria-degli-illeciti-edilizi)

[5] TAR Campania (NA) Sez. IV n.5708 del 13 dicembre 2016 from Lexambiente (https://lexambiente.it/index.php/materie/ambiente-in-genere/giurisprudenza-amministrativa-tar92/ambiente-in-genere-cave-e-provvedimento-di-sospensione-dei-lavori-estrattivi)

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2016:121:FIN

[7] https://circabc.europa.eu/ui/group/cafdbfbb-a3b9-42d8-b3c9-05e8f2c6a6fe/library/bd6a3516-b2c9-451d-a49d-aa0489a6a735/details

3.4. Extended questionnaire-based survey results - General overview

The survey 42 responses were obtained from 7 countries (Figure 2). Results are reported in figures contained in this section.

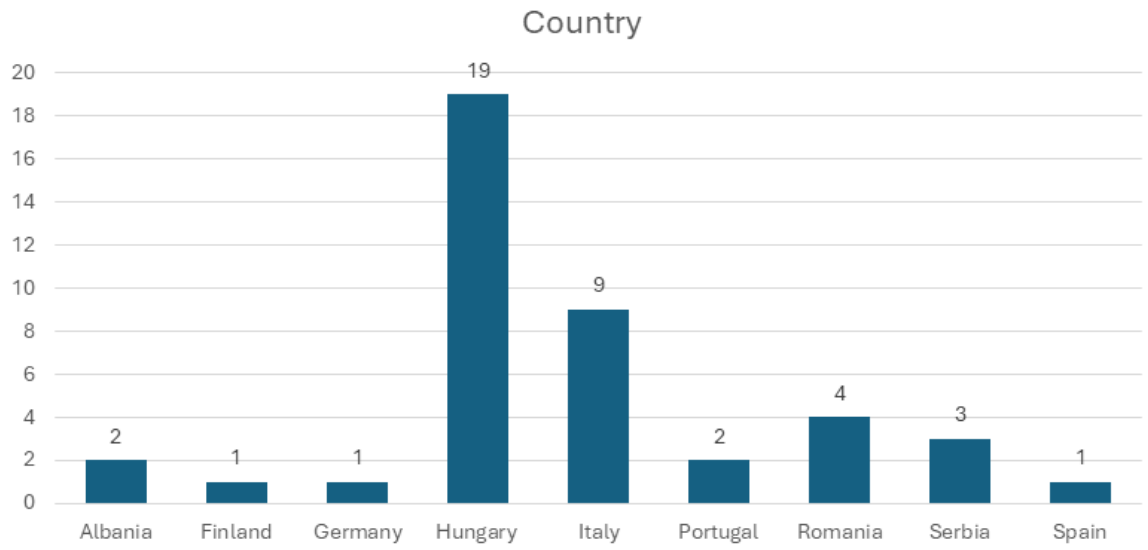


Figure 2. Distribution of respondents country

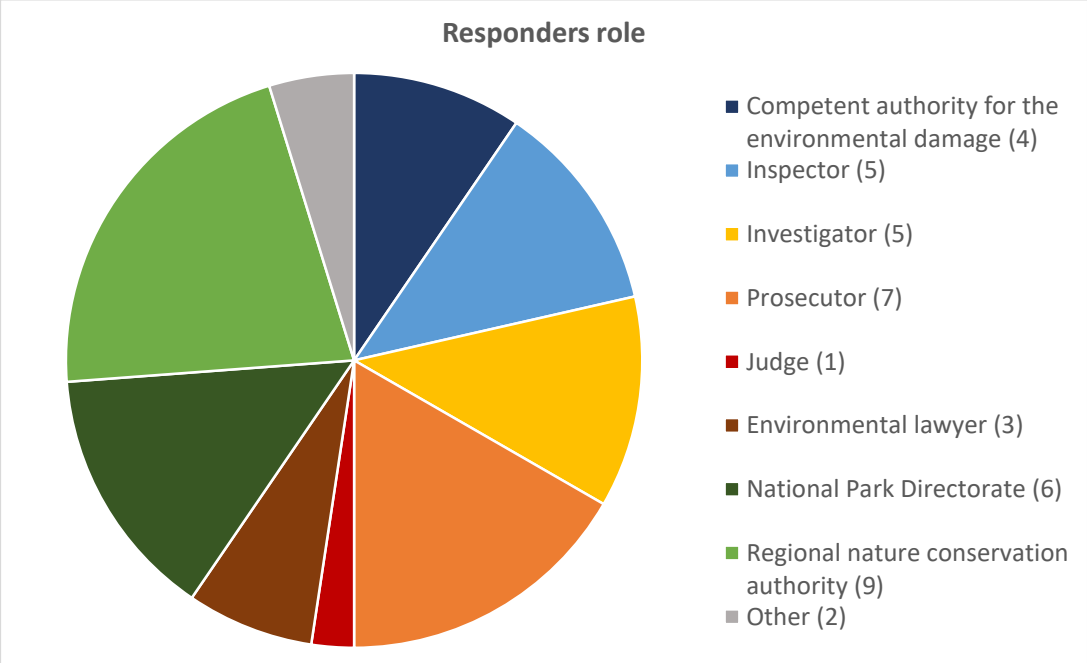


Figure 3. Distribution of respondents role

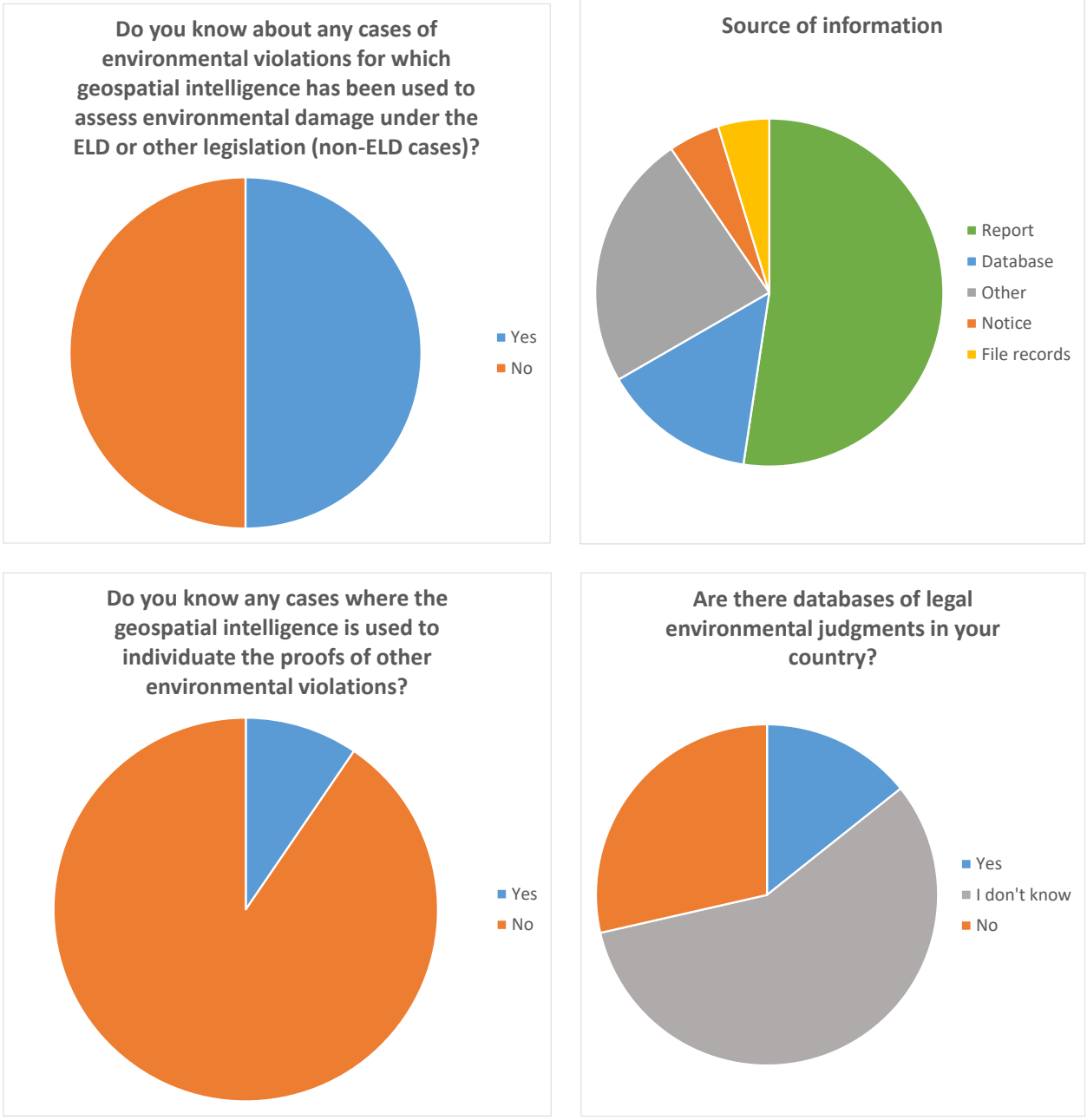


Figure 4. Distribution of responses regarding the reporting of cases for which geospatial intelligence was used

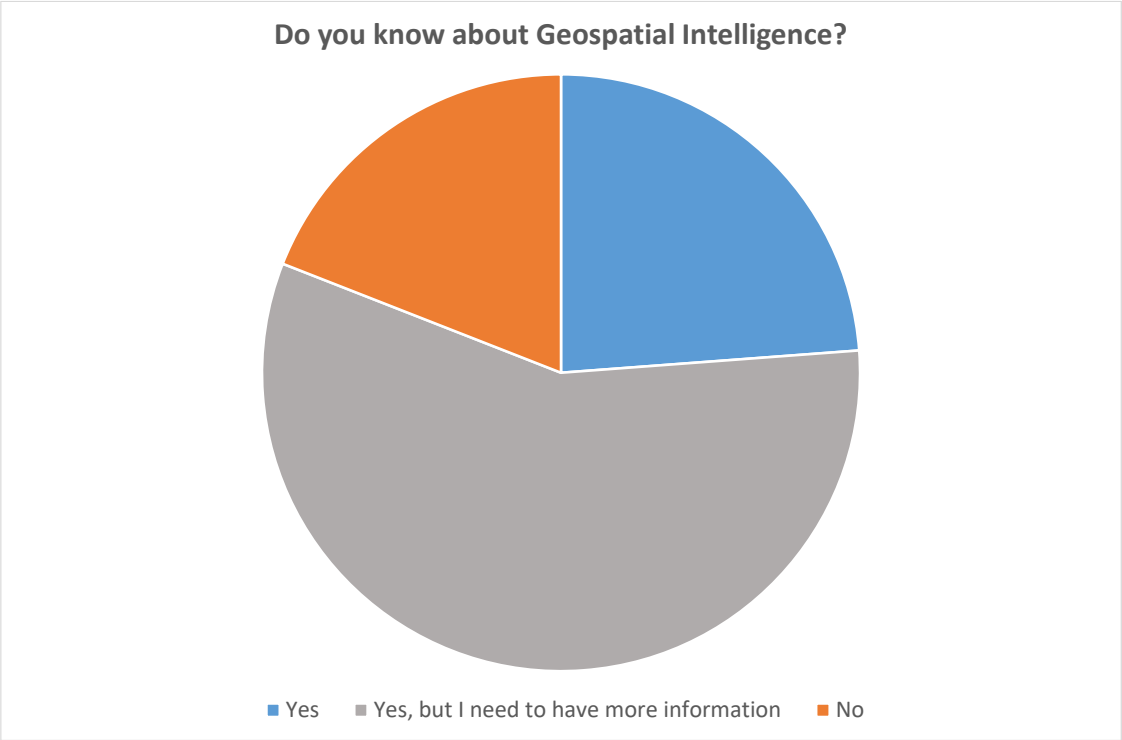
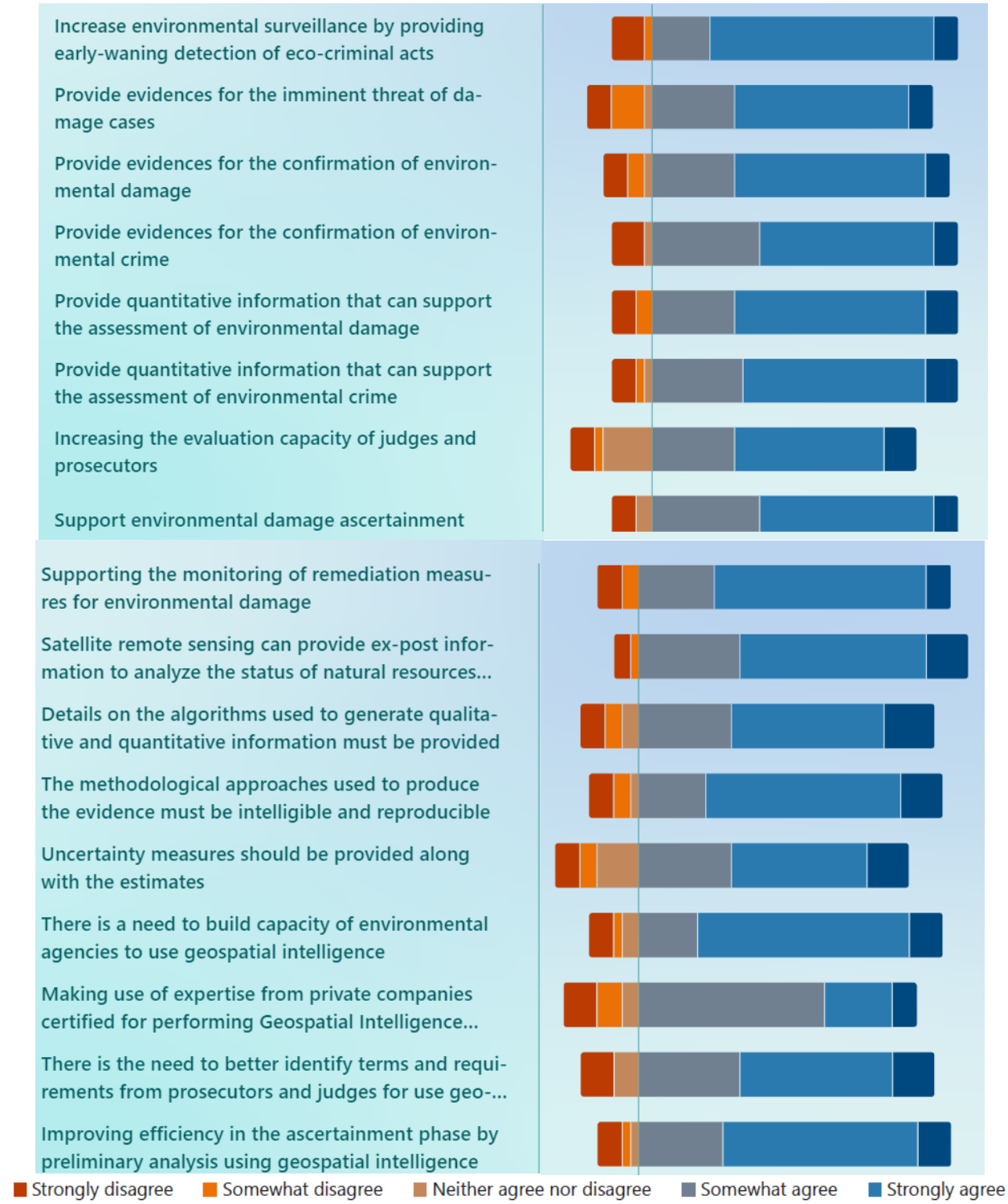


Figure 5. Distribution of answers related to the knowledge of geospatial intelligence

Distribution of respondents role (Figure 3) shows that various entities involved in the assessment of environmental violations and environmental damage processes answered the extended questionnaire, without any role prevalence. A total of 21 cases of environmental violation for which geospatial intelligence has been used to assess environmental damage were collected (Figure 4), whose source of information comes mainly from reports. A total of 4 cases where the geospatial intelligence is used to individuate the proofs of other environmental violations were collected. Most of the respondents said they don't know about the availability of databases of legal environmental judgements in their own country.

While only 25 percent of respondents said they knew about geospatial intelligence, more than 50 percent said they wanted to have more information about the capacity of such technology (Figure 5). With respect to the point of view on perspectives offered by geospatial intelligence techniques (Figure 6), there is an overall agreement on all items. The need to build capacity of environmental agencies to use geospatial intelligence was one of the items with the greatest consensus.



* for full description of truncated items see Annex III

Figure 6. Point of view on perspectives offered by geospatial intelligence techniques

4. Description of cases

A more in-depth investigation was carried out for selected cases among the collected through the extended questionnaire, possibly with additional information provided by direct contact with the respondents (20 cases among the total 42 cases collected by the questionnaire responses). The analysis also included some cases identified by the direct contribution of project members (8 cases).

For each of the 28 cases selected for the reporting, all the relevant information (legal/procedural, technical) is organized in a datasheet, provided in paragraph 4.1, consisting of the following sections:

- Case overview: general overview of the case with a description of the event and the involved natural resources
- Application of geospatial intelligence: extensive description of how the geospatial intelligence is applied in the examined case
- Procedural and legal specification: distinction between ELD and non-ELD case and legal and administrative procedures, with the indication of the stage of the procedure
- Technical specifications: technical elements both relative to the data used and the analysis realized
- Key points: section that summarize the relevant aspects of the application of the geospatial intelligence techniques

4.1. Informative datasheets

<table>
<tr><td rowspan="4">CASE NO. 1
 
INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE</td><td>Country</td><td>Italy</td></tr>
<tr><td>Contributor</td><td>ISPRA (Italian National Institute for the</td></tr>
<tr><td>Role of contributor</td><td>Environmental Agency</td></tr>
<tr><td>Source of information</td><td>Technical report</td></tr>
<tr><td colspan="3">CASE OVERVIEW</td></tr>
<tr><td colspan="3">Realization and non-compliant management of landfills in a ravine located in a Natura 2000 area, resulting in alterations to the morphology of the site due to the creation of anthropic hills made of waste. Over time, large quantities of waste have collapsed, leading to further morphological changes in the ravine and the river flowing at the bottom, as well as negative impacts on the vegetation present in the area.</td></tr>
<tr><td colspan="2">Type of event</td><td>Violation (non-compliant waste management)</td></tr>
<tr><td colspan="2">Reference date of the event</td><td>From 1995, ascertainment in 2021</td></tr>
<tr><td colspan="2">Site interested by the event</td><td>Natural area</td></tr>
<tr><td colspan="2">Natural resources</td><td>Natural habitats</td></tr>
<tr><td colspan="3">APPLICATION OF GEOSPATIAL INTELLIGENCE</td></tr>
<tr><td colspan="3">A two phases study was conducted. In the first phase, GIS analyses were carried out based on the data available from the regional Territorial Information Service. A digital terrain model (DTM) representative of the morphology of the ravine was calculated to examine changes due to landfills, and a vegetation analysis was performed through the interpretation of remote sensing images to identify the different types of vegetation present in the area. In the second phase, an in-situ photobiological survey and UAS monitoring were conducted. The photobiological survey was carried out both in areas with landfills and in additional unaffected areas considered “spatial blanks”, allowing for the reconstruction of the coverage percentage of various plant species present in the region. The UAS monitoring enabled the acquisition of images and videos used to produce a high-resolution orthomosaic, which was utilized to identify plant species in areas inaccessible by in-situ surveys and to detail the morphology of the ravine, useful for detecting any erosion phenomena. The combined approach, based on GIS analyses, in-situ surveys, and UAS monitoring, allowed the assessment of an environmental damage to the natural habitat 9540 “Mediterranean pine forests with endemic Mesogean pines”, the extent of which was estimated, and it was equal to 5 ha (85% respect the whole habitat in ravine).</td></tr>
<tr><td colspan="2">Procedure requested by</td><td>Environmental Agency</td></tr>
</table>

Procedure realized by	Environmental Agency
PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal procedure (establishment of the Ministry of the environment, national competent authority for the environmental damage, as a civil party in a criminal proceeding).
Stage of procedure	The first-grade judgement is on going
Additional information	Not available
TECHNICAL SPECIFICATIONS	
Data used	Data from regional Territorial Information Service; in-situ survey and UAV imagery
Type of analysis	Qualitative and quantitative
Methodological approach	Data analysis from photobiological survey: application of multivariate statistics methods. Data analysis from UAS survey: photogrammetric software
Algorithms used	Structure from Motion (SfM) algorithms for the elaboration of images obtained from drone monitoring
Uncertainty estimate	Not available
Produced information	Extension of area of the damaged natural habitat
KEY POINTS	

- Case type: individuation of the proofs of the environmental damage
- Event type: violation (non-compliant waste management)
- Type of procedure: legal
- Provider of geospatial techniques: environmental agency
- Source of data used: in-situ photobiological surveys and UAV imagery
- Analysis realized or approaches adopted: multivariate statistics methods, usage of a photogrammetric software and geostatistical analysis
- Information produced using GEOINT: quantitative estimate of the area of the impacted natural habitats

CASE NO. 2 SUPPORT IN ENVIRONMENTAL DAMAGE REMEDIATION PLANNING	Country	Italy
	Contributor	ISPRA (Italian National Institute for the Environmental Protection
	Role of contributor	Environmental Agency
	Source of information	Technical report
CASE OVERVIEW		
Non-compliant management of an aggregate quarry, resulting in alterations to the morphology and naturalness of the territory, both in terms of exceeding the spatial and temporal limits imposed on extraction activities and in terms of the failure to implement restoration measures for the quarry.		
Type of event	Violation (unauthorized and/or non-compliant activities - mining)	
Reference date of the event	Since 1993 (first ascertainment)	
Site interested by the event	Quarry	
Natural resources	Plant species and soil (morphology)	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Realization of topographic surveys using GPS and bathymetric surveys to calculate the areas affected by illegal extractions and to compute the volume of material needed to restore the area.		
Procedure requested by	Prosecutor office	
Procedure realized by	Non-institutional experts	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (Law n. 349/86 – art. 18)	
Type of procedure	Legal procedure (civil proceedings to individuate the remediation measures)	
Stage of procedure	On going proceeding	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Data from GPS surveys and bathymetric surveys	
Type of analysis	Quantitative	

Methodological approach	Photogrammetric techniques for the elaboration of data from GPS
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Estimate of the area interested by illegal excavations (about 13 ha) and estimate of the volume of materials needed to restore the morphology of the area (about 500.000 m^3)

KEY POINTS

- Case type: support in environmental damage remediation planning
- Event type: violation (unauthorized and/or non-compliant activities - mining)
- Type of procedure: legal
- Provider of geospatial techniques: non-institutional experts
- Source of data used: GPS and bathymetric surveys
- Analysis realized or approaches adopted: photogrammetric techniques for the elaboration of data from GPS
- Information produced using GEOINT: quantitative estimate of the area impacted by morphological alterations and quantitative estimate of the volume of materials needed to restore the morphology of the area

CASE NO. 3 GENERAL ASSESSMENT OF THE EVENT	Country	Italy
	Contributor	ISPRA (Italian National Institute for the Environmental Protection and Research)
	Role of contributor	Environmental Agency
	Source of information	Technical report
CASE OVERVIEW		
Cut of vegetation in an abandoned industrial area.		
Type of event	Violation (unauthorized and/or non-compliant activities - logging)	
Reference date of the event	2021	
Site interested by the event	Industrial area	
Natural resources	Plant species	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Use of satellite imagery to estimate reduction in vegetation cover, seen as a decrease in the area covered by photosynthetically active vegetation. Estimate of loss in terms of plant leaf area index, complemented with uncertainty estimates.		
Procedure requested by	Environmental Agency	
Procedure realized by	Environmental Agency	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (further investigation needed)	
Type of procedure	Administrative procedure	
Stage of procedure	Order of the Ministry (competent authority for the environmental damage) to operator, to realize specific survey to determine the types of species interested by the illegal logging	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Time series of Copernicus Sentinel-2 MSI (optical multispectral) satellite imagery (free and open access distribution policy)	

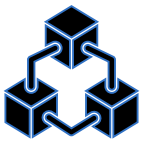
Type of analysis	Quantitative
Methodological approach	Change detection analysis by means of time-series analysis of two estimated biophysical parameters
Algorithms used	The “Biophysical Processor” available in SNAP STEP software
Uncertainty estimate	Produced quantitative uncertainty estimates
Produced information	Quantitative estimation of the change in biophysical parameters named “Fraction of green vegetation Cover (FCover)” and “Leaf Area Index (LAI)”
KEY POINTS	
• Case type: general assessment of the event • Event type: violation (unauthorized and/or non-compliant activities - logging) • Type of procedure: administrative • Provider of geospatial techniques: environmental agency • Source of data used: open-access satellite imagery • Analysis realized or approaches adopted: change detection analysis • Information produced using GEOINT: quantitative estimate of the area interested by illegal logging and quantitative estimate of the change in biophysical parameters (FCover and LAI)	

CASE NO. 4  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Italy
	Contributor	ISPRA (Italian National Institute for the Environmental Protection and Research)
	Role of contributor	Environmental Agency
	Source of information	Technical report
CASE OVERVIEW		
Illegal activities of extraction and trade of the protected species *Lithophaga lithophaga* (date mussel), leading to the reduction of the population of the species and the destruction of reefs.		
Type of event	Violation (unauthorized and/or non-compliant activities - fishing)	
Reference date of the event	Ascertainment in 2020-2021 (the illegal activity covers a period of 20 years)	
Site interested by the event	Natural area	
Natural resources	Animal species	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Execution of an underwater survey to acquire images of the damaged reef. Through the processing of images related to the damaged areas, the density of destroyed date mussel populations was estimated by counting the number of perforations within standard squares (30 cm sides), arranged according to a random probability sampling scheme.		
Procedure requested by	Prosecutor office	
Procedure realized by	University	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	ELD case	
Type of procedure	Legal procedure (establishment of the Ministry as a civil party in criminal proceedings)	
Stage of procedure	First order of judgement is ended	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Images from underwater surveys	
Type of analysis	Quantitative	

Methodological approach	Usage of a software for the analysis of images and for statistical analysis
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Estimation of area where the date mussels are interested by an environmental damage

KEY POINTS

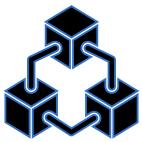
- Case type: individuation of the proofs of the environmental damage
- Event type: violation (unauthorized and/or non-compliant activities - fishing)
- Type of procedure: legal
- Provider of geospatial techniques: university
- Source of data used: underwater surveys
- Analysis realized or approaches adopted: statistical analysis and imagery analysis
- Information produced using GEOINT: quantitative estimate of the area impacted by illegal extraction of date mussels

CASE NO. 5  GENERAL ASSESSMENT OF THE EVENT	Country	Italy
	Contributor	ISPRA (Italian National Institute for the Environmental Protection and Research)
	Role of contributor	Environmental Agency
	Source of information	Technical report
CASE OVERVIEW		
Major fire accident in a chemical plant situated in an industrial zone, alongside a river, due to overflow from the first flush rainwater harvesting tank, some untreated fire extinguishing wastewaters was spilled into the river.		
Type of event	Incident (fire)	
Reference date of the event	2020	
Site interested by the event	Industrial area	
Natural resources	Water	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Satellite optical multispectral data could be used to monitor atmospheric fire plume dispersal patterns, and the area affected by fire extinguishing wastewaters plume dispersal in rivers and coastal waters.		
Procedure requested by	Environmental Agency	
Procedure realized by	Environmental Agency	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (further investigation needed)	
Type of procedure	Administrative procedure	
Stage of procedure	Order of the Ministry (competent authority for the environmental damage) to operator, to conduct surveys to analyse the environmental status of the water	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Open-access satellite imagery (acquired by optical multispectral sensor)	

Type of analysis	Not available
Methodological approach	Radiometric analysis
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Querying satellite data catalogues (distributed by EUMETSAT, Copernicus Programme, NASA) to identify available cloud free data. No information could be produced due to persistence of cloud cover on the area of interest

KEY POINTS

- Case type: general assessment of the event
- Event type: incident (fire)
- Type of procedure: administrative
- Provider of geospatial techniques: environmental agency
- Source of data used: open-access satellite imagery
- Analysis realized or approaches adopted: radiometric analysis
- Information produced using GEOINT: monitoring of plume was not possible due to persistent cloud cover (technological limitation in the use of remote sensing optical multispectral data)

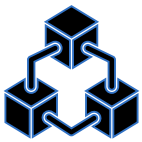
CASE NO. 6  GENERAL ASSESSMENT OF THE EVENT	Country	Italy
	Contributor	ARPA Lombardia
	Role of contributor	Environmental Protection Agency of Lombardy
	Source of information	Direct case reporting

CASE OVERVIEW	
Case of illegality in an authorized waste treatment facility. The specific case arose to the attention from the wide scale surveillance activities related to waste management performed by ARPA Lombardia. Moreover, a specific control at the site was requested by Prosecutor Office in the framework of an open legal procedure; among other criticalities, also environmental damage evaluation procedure is open (actual evaluation feasible only after the removal of waste from the site).	
Type of event	Violation (non-compliant waste management)
Reference date of the event	2019-2021
Site interested by the event	Waste Treatment Plant
Natural resources	Water; Soil

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Geospatial Intelligence produce proofs of Environmental Non-Compliance, particularly in relation to wastes disposal and total amount. Among others, multitemporal analysis based on high resolution satellite data, GIS evaluation related to comparison between actual and authorized sites for waste disposal, and waste volume calculation based on UAV photogrammetry were performed. In a second moment, after the removal of waste, would have been activated the environmental damage procedure about water or soil contamination.	
Procedure requested by	Prosecutor office
Procedure realized by	Personal of ARPA Lombardia

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case (further investigation needed)

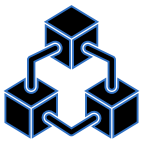
Type of procedure	Legal procedure
Stage of procedure	On going
Additional information	The sites were overfilled by wastes; the procedure to understand the environmental damage will not begin before the remotion of exceeding wastes
TECHNICAL SPECIFICATIONS	
Data used	UAV imagery; high resolution satellite and airborne imagery
Type of analysis	Quantitative: defining the wastes volume through photogrammetry
Methodological approach	UAS survey; standard photogrammetry post-processing; planimetric and volumetric evaluations in GIS environment
Algorithms used	UAV photogrammetry (structure from motion standard approach); Volume calculations with 2.5 volume method from the point cloud
Uncertainty estimate	GSD from UAS survey less than 1 cm; resolution of the raster product derived from UAV photogrammetry: 2 cm; applied internal standard procedures for volume accuracy estimation
Produced information	Estimated volume of dumped waste
KEY POINTS	
• Case type: general assessment of the event • Event type: violation (non-compliant waste management) • Type of procedure: legal • Provider of geospatial techniques: environmental agency • Source of data used: UAV imagery, high resolution satellite and airborne imagery • Analysis realized or approaches adopted: UAV photogrammetry • Information produced using GEOINT: quantitative estimate of the waste volume, provided with uncertainty estimates	

CASE NO. 7  GENERAL ASSESSMENT OF THE EVENT	Country	Italy
	Contributor	ARPA Lombardia
	Role of contributor	Environmental Agency
	Source of information	Direct case reporting
CASE OVERVIEW		
Suspicious impact to the vegetation surrounding the city of Cremona due to air pollution.		
Type of event	Air emissions	
Reference date of the event	2023	
Site interested by the event	Industrial Area	
Natural resources	Natural habitats	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Analyses of NDVI time series calculated from satellite imagery to verify potential deterioration of the vegetation quality during the time (multi-annual analysis); no significant anomalies detected in the area of interest.		
Procedure requested by	Citizens committee	
Procedure realized by	ARPA and ISPRA	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Not-ELD case	
Type of procedure	Legal procedure	
Stage of procedure	Concluded	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Copernicus Sentinel-2 MSI (optical multispectral) satellite imagery	

	(free and open access distribution policy)
Type of analysis	Qualitative
Methodological approach	Geostatistical analysis; time-series analysis; biophysical parameter estimate
Algorithms used	Calculation of Normalized Difference Vegetation Index (NDVI), from Copernicus Sentinel-2 MSI L2A satellite dataset
Uncertainty estimate	Not available
Produced information	Detailed qualitative information produced

KEY POINTS

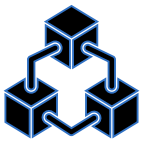
- Case type: general assessment of the event
- Event type: air emissions
- Type of procedure: legal
- Provider of geospatial techniques: environmental agency
- Source of data used: open-access satellite imagery
- Analysis realized or approaches adopted: geostatistical analysis; time-series analysis
- Information produced using GEOINT: qualitative estimate of vegetation deterioration

CASE NO. 8  **GENERAL ASSESSMENT OF THE EVENT**	Country	Italy
	Contributor	ARPA Lombardia
	Role of contributor	Environmental Agency
	Source of information	Direct case reporting
CASE OVERVIEW		
Illegal wastes disposal.		
Type of event	Violation (non-compliant waste management)	
Reference date of the event	2024	
Site interested by the event	Natural area	
Natural resources	Soil	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Multitemporal analysis using regional aerial orthomosaics, publicly available high spatial resolution satellite imagery, and Google Street View, to understand the evolution of the waste disposal in the area.		
Procedure requested by	ISPRA	
Procedure realized by	ARPA Lombardia	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case	
Type of procedure	Legal procedure	
Stage of procedure	Not available	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Aerial orthomosaics, open-access satellite imagery at high spatial	

	resolution and Google Street View time series images
Type of analysis	Qualitative
Methodological approach	Time-series analysis
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Qualitative information produced

KEY POINTS

- Case type: general assessment of the event
- Event type: violation (non-compliant waste management)
- Type of procedure: legal
- Provider of geospatial techniques: environmental agency
- Source of data used: regional aerial images, publicly available high resolution satellite imagery and Google Street View time series images
- Analysis realized or approaches adopted: time-series analysis
- Information produced using GEOINT: qualitative estimate of the area interested by waste disposal

CASE NO. 9  **GENERAL ASSESSMENT OF THE EVENT**	Country	Italy
	Contributor	Arpa Piemonte
	Role of contributor	Environmental Agency
	Source of information	Direct case reporting
CASE OVERVIEW		
Evaluation of the volume of non-compliant storage of flammable solid wastes after a fire in a waste management plant.		
Type of event	Violation and incident (non-compliant waste management)	
Reference date of the event	Mid 2019	
Site interested by the event	Waste management plant	
Natural resources	Soil	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Support the general assessment of the event, produce proofs of infringement of environmental regulations.		
Procedure requested by	Prosecutor office	
Procedure realized by	Environmental agency	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case	
Type of procedure	Legal procedure	
Stage of procedure	Unknown	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		

Data used	Open-access satellite imagery
Type of analysis	Quantitative (experimental)
Methodological approach	Waste volume assessment
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Estimated volume of burned waste

KEY POINTS

- Case type: general assessment of the event
- Event type: violation and incident (non-compliant waste management)
- Type of procedure: legal
- Provider of geospatial techniques: environmental agency
- Source of data used: open-access satellite imagery
- Analysis realized or approaches adopted: waste volume assessment (experimental)
- Information produced using GEOINT: quantitative estimate of the waste volume, without uncertainty estimates

CASE NO. 10  **INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE**	Country	Portugal
	Contributor	IGAMAOT
	Role of contributor	Environmental Inspectorate
	Source of information	Criminal investigation report

CASE OVERVIEW	
Dumping and burial of waste containing hazardous substances.	
Type of event	Violation (non-compliant waste management)
Reference date of the event	2017-2023
Site interested by the event	Landfill
Natural resources	Groundwater; Soil

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Establishment of the period in which the dumping and burial of waste took place: computation of a digital terrain model by UAV photogrammetry, thermal assessment of the landfill, waste volume assessment.	
Procedure requested by	IGAMAOT and other state entity
Procedure realized by	Environmental inspectorate; non-institutional experts

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case
Type of procedure	Legal
Stage of procedure	Prosecution concluded, awaiting trial
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	Orthomosaics available in Google Earth; UAV orthomosaics; thermal acquisitions
Type of analysis	Qualitative; Quantitative
Methodological approach	Photogrammetry; time-series analysis; biophysical parameter estimate; waste volume assessment
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Detailed qualitative and/or qualitative information produced; thermal map; Estimated volume of dumped waste

KEY POINTS

- Case type: individuation of the proofs of the environmental damage
- Event type: violation (non-compliant waste management)
- Type of procedure: legal
- Provider of geospatial techniques: environmental inspectorate and private company
- Source of data used: imagery available in Google Earth and UAV imagery
- Analysis realized or approaches adopted: time series analysis
- Information produced using GEOINT: quantitative estimate of the waste volume, thermal map

CASE NO. 11	Country	Germany
	Contributor	Public Prosecutor's Office Frankfurt am Main
	Role of contributor	Prosecutor
INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Source of information	File records, not published

CASE OVERVIEW	
Illegal disposal of hazardous waste from a construction site.	
Type of event	Violation (non-compliant waste management)
Reference date of the event	July - October 2019
Site interested by the event	Natural area
Natural resources	Soil

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Description and describe the extent of damage on the site, through the use of UAS surveys.	
Procedure requested by	Not available
Procedure realized by	Not available

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Administrative procedure
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	UAV imagery
Type of analysis	Qualitative; Quantitative
Methodological approach	UAV photogrammetry; geostatistical analysis
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Qualitative and qualitative information produced to assess and characterize the extent of the damaged area

KEY POINTS

- Case type: individuation of the proofs of the environmental damage
- Event type: violation (non-compliant waste management)
- Type of procedure: administrative
- Source of data used: UAV imagery
- Analysis realized or approaches adopted: UAV photogrammetry, geostatistical analysis
- Information produced using GEOINT: characterize and estimate the extent of the area interested by waste disposal

CASE NO. 12  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Finland
	Contributor	Prosecution Authority of Finland, Prosecution District of Southern Finland
	Role of contributor	Prosecutor
	Source of information	Report from city surveyors

CASE OVERVIEW	
Contaminated surplus soil (100,000 m^3) piled illegally next to city drinking water intake	
Type of event	Violation (non-compliant waste management)
Reference date of the event	September 2015 - November 2016
Site interested by the event	Natural area
Natural resources	Groundwater

APPLICATION OF GEOSPATIAL INTELLIGENCE	
On request made by pre-trial investigation authorities, city surveyors used satellite data to measure the amount of contaminated surplus soil dumped in the area, resulting in 100,000 m^3 of illegally dumped soil.	
Procedure requested by	Prosecutor office
Procedure realized by	City surveyors

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	In-situ data collected in specific surveys realized after the damage event; satellite imagery
Type of analysis	Quantitative
Methodological approach	Geostatistical analysis
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Estimated volume of dumped contaminated surplus soil

KEY POINTS

- Case type: individuation of the proofs of the environmental damage
- Event type: violation (non-compliant waste management)
- Type of procedure: legal
- Provider of geospatial techniques: city surveyors
- Source of data used: in-situ surveys data, satellite imagery
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: quantitative volume estimate of dumped contaminated surplus soil

CASE NO. 13 SUPPORT IN ENVIRONMENTAL DAMAGE REMEDIATION PLANNING	Country	Hungary
	Contributor	Government Office
	Role of contributor	Competent authority for the environment protection and nature conservation
	Source of information	Notification of the Hungarian State Treasury

CASE OVERVIEW	
In a protected and Natura 2000 area, grass was broken up, as a strip of land was ploughed from the neighbouring field. In order to restore it, an official procedure was initiated, which ended with the issuance of a binding decision.	
Type of event	Violation (unauthorized and/or non-compliant activities)
Reference date of the event	22/06/2023
Site interested by the event	Natura 2000 site
Natural resources	Natural habitats

APPLICATION OF GEOSPATIAL INTELLIGENCE	
The Hungarian State Treasury made its notification to the nature conservation authority based on the coverage of permanent sensitive lawn areas in the Land Parcel Identification System. The land office measured the area affected by the damage with GPS device and analyzed the data using GIS software.	
Procedure requested by	The Hungarian State Treasury
Procedure realized by	Not available

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal procedure
Stage of procedure	Issuance of a binding decision
Additional information	In a protected and Natura 2000 area, grass was broken up, as a strip of land was ploughed from the neighbouring field. In order

	to restore it, an official procedure was initiated, which ended with the issuance of a binding decision.
TECHNICAL SPECIFICATIONS	
Data used	Field data collected in specific surveys realized after the damage event, using a GPS device
Type of analysis	Quantitative
Methodological approach	Field survey; geostatistical analysis. Identify geolocation of the damaged area from GPS data and generate mapping representation.
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Assess the extent of the damaged area
KEY POINTS	
• Case type: support in environmental damage remediation planning • Event type: violation (unauthorized and/or non-compliant activities) • Type of procedure: legal • Provider of geospatial techniques: Government Office • Source of data used: geolocated surveys • Analysis realized or approaches adopted: geostatistical analysis • Information produced using GEOINT: quantitative estimate of the area of the impacted natural habitats	

CASE NO. 14  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Hungary
	Contributor	Government Office of Veszprém County
	Role of contributor	Competent authority for the environment protection and nature conservation
	Source of information	Nature conservation officer notification

CASE OVERVIEW	
Unauthorized construction earthworks destroyed a natural resource (well, spring).	
Type of event	Incident (unauthorized and/or non-compliant activities - constructions)
Reference date of the event	2023
Site interested by the event	Natural area
Natural resources	Surface water

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Time series of Copernicus Sentinel-2 satellite images to identify a drastic change in surface coverage; the infra-red radiometric interval in satellite imagery indicates earthworks.	
Procedure requested by	Government Office of Veszprém County
Procedure realized by	National Park Administration

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case
Type of procedure	Legal procedure
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	Copernicus Sentinel-2 MSI (optical multispectral) satellite imagery (free and open access distribution policy); geolocated surveys
Type of analysis	Qualitative and quantitative
Methodological approach	Time series analysis; change detection
Algorithms used	Comparison between data from surveys and the threshold values defined by the law. The infra-red spectral interval indicates earthworks. Analysis based on the identified date and the real estate registry data. Use of remote sensing data and field data collected in specific surveys realized after the damage event.
Uncertainty estimate	Not available
Produced information	Land use change detection by the infrared and NDVI spectral index, that allowed to identify the absence of vegetation/habitats

KEY POINTS

- Case type individuation of the proofs of the environmental damage
- Event type: incident (unauthorized and/or non-compliant activities - constructions)
- Type of procedure: legal
- Provider of geospatial techniques: National Park Administration
- Source of data used: open-access satellite imagery, geolocated surveys
- Analysis realized or approaches adopted: time series analysis, change detection by the infrared and NDVI spectral index
- Information produced using GEOINT: identification of changes in surface coverage

CASE NO. 15 GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Rapid Response and Special Police Services National Bureau Of Investigation
	Role of contributor	Investigators
	Source of information	Database

CASE OVERVIEW	
Disposal and burial of hazardous waste.	
Type of event	Violation (non-compliant waste management)
Reference date of the event	2021
Site interested by the event	Waste management site
Natural resources	Soil

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Use of UAS surveys in the area.	
Procedure requested by	Rapid Response and Special Police Services National Bureau Of Investigation
Procedure realized by	Investigators

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case
Type of procedure	Legal
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	UAV imagery

Type of analysis	Qualitative and quantitative
Methodological approach	Geostatistical analysis of remote sensing data
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Assess extent of damaged area

KEY POINTS

- Case type: general assessment of the event
- Event type: violation
- Type of procedure: legal
- Provider of geospatial techniques: investigators
- Source of data used: UAV imagery
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: estimate of the area interested by waste disposal

CASE NO. 16  **INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE**	Country	Hungary
	Contributor	Government Office of Vas County Department for Environment and Nature protection
	Role of contributor	Competent authority for the environment protection and nature conservation
	Source of information	Database, repository, reports

CASE OVERVIEW	
Illegal lawn breaking in a protected area.	
Type of event	Incident (unauthorized and/or non-compliant activities)
Reference date of the event	2023 (fall season)
Site interested by the event	Natural area
Natural resources	Natural habitats

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Use of satellite images time series available in Google Earth through the time slider tool.	
Procedure requested by	Government Office of Vas County Department for Environment and Nature protection
Procedure realized by	Not available

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal and administrative procedure
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	Satellite images time series available from Google Earth
Type of analysis	Qualitative
Methodological approach	Geostatistical analysis to assess the extent of damaged habitat
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Estimation of the area of the damaged habitat interested by illegal breaking

KEY POINTS

- Case type: individuation of the proofs of the environmental damage
- Event type: incident (unauthorized and/or non-compliant activities)
- Type of procedure: legal and administrative
- Source of data used: orthomosaics available in Google Earth
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: qualitative estimate of the area of the damaged habitat

CASE NO. 17 GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Government Office of Bács-Kiskun
	Role of contributor	Competent authority for the environment protection and nature conservation
	Source of information	Park ranger reports (nature conservation officer notification)
CASE OVERVIEW		
Grass degradation in a protected and Natura 2000 area.		
Type of event	Violation (unauthorized and/or non-compliant activities)	
Reference date of the event	November 2023 - December 2023	
Site interested by the event	Natural area	
Natural resources	Natural habitats	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Use of satellite images time series available in Google Earth through the time slider tool.		
Procedure requested by	Government Office of Bács-Kiskun	
Procedure realized by	Kiskunság National Park Administration	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (Law No. LIII of 1996 on Nature Conservation)	
Type of procedure	Legal procedure	
Stage of procedure	Not available	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Satellite images time series available from Google Earth	
Type of analysis	Qualitative and quantitative	

Methodological approach	Geostatistical analysis; satellite image time series analysis. Field survey: recording of HD72 Hungarian Projection System coordinates (geolocation); location determination; area measurement.
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Assessment of extent of damaged area
KEY POINTS	
• Case type: general assessment of the event • Event type: violation (unauthorized and/or non-compliant activities) • Type of procedure: legal • Source of data used: orthomosaics available in Google Earth, geolocated surveys • Analysis realized or approaches adopted: geostatistical analysis • Information produced using GEOINT: quantitative and qualitative estimate of the area of vegetation interested by impacts	

CASE NO. 18  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Hungary
	Contributor	Fertő-Hanság National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Nature conservation officer notification (Park ranger reports)

CASE OVERVIEW	
Damage to the protected natural grassland due to unauthorized activity. The violator illegally used a protected grassland area, managed by the Fertő-Hanság National Park Directorate, its activities lasting many years and leading to damage to the natural grassland, despite repeated official notices and the imposition of fines.	
Type of event	Violation (unauthorized and/or non-compliant activities)
Reference date of the event	2020-2023
Site interested by the event	Natural area
Natural resources	Natural habitats
APPLICATION OF GEOSPATIAL INTELLIGENCE	
Description and characterization of the territorial context.	
Procedure requested by	Fertő-Hanság National Park Directorate
Procedure realized by	Not available
PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal procedure
Stage of procedure	Not available
Additional information	Nature conservation management authority cooperates with

	regional Government Office in official procedures and performed the data collection
TECHNICAL SPECIFICATIONS	
Data used	Spatially explicit information layers; field data collected in specific surveys realized after the damage event
Type of analysis	Qualitative and quantitative
Methodological approach	Geostatistical analysis in GIS software. Evaluation of environmental damage. Prior to the on-site inspection, exact size of the affected area was determined by available spatially explicit information layers (e.g. parcel numbers, orthophotos, species database, Natura 2000 sites, habitat maps, etc.). This served as the basis for the official regulatory procedure.
Algorithms used	ArcGIS software
Uncertainty estimate	Not available
Produced information	Description and characterization of the territorial context, assess the extent of damaged area
KEY POINTS	
• Case type: individuation of the proofs of the environmental damage • Event type: violation (unauthorized and/or non-compliant activities) • Type of procedure: legal • Source of data used: aerial imagery and geolocated surveys • Analysis realized or approaches adopted: geostatistical analysis • Information produced using GEOINT: quantitative estimate of the area interested by the impacts and description of the territorial context	

CASE NO. 19  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Hungary
	Contributor	Hortobágyi National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Park ranger reports

CASE OVERVIEW	
Landfill on the habitat of a strictly protected ground-dwelling molerat species. The violation site owner declared he was only using an already existing dumping site in the area. Regular monitoring of habitat in the violation site allowed to establish the presence of a newly formed hill, as a consequence of landfill. Satellite images allowed to generate the evidence, by assessing the week when the violation was done, and the use of extra soil which was contaminated with construction of waste dumping site.	
Type of event	Violation (non-compliant waste management)
Reference date of the event	June 2022
Site interested by the event	Natural area (agro-ecosystem)
Natural resources	Impacts on animal species: Lesser Molerat (Nannospalax leucodon), the most threatened vertebrate of Hungary. According to the IUCN Red List, it is a critically endangered rodent and is endemic to the Carpathian Basin. It is strictly protected in Hungary, according to the law its value is 1,000,000 Ft/individual.
APPLICATION OF GEOSPATIAL INTELLIGENCE	
Use of Copernicus Sentinel-2 satellite images to determine the rough date of the work.	
Procedure requested by	Hortobágyi National Park Directorate
Procedure realized by	Not available
PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case (Law No. LIII of 1996 on Nature Conservation)

Type of procedure	Legal procedure
Stage of procedure	The owner is currently forced to remove excess waste
Additional information	Not available
TECHNICAL SPECIFICATIONS	
Data used	Copernicus Sentinel-2 MSI (optical multispectral) satellite imagery (free and open access distribution policy)
Type of analysis	Qualitative
Methodological approach	Determine the period when the violation occurred from satellite acquisitions
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Assessing of the period when the violation was done
KEY POINTS	
• Case type: individuation of the proofs of the environmental damage • Event type: violation (non-compliant waste management) • Type of procedure: legal • Source of data used: open-access satellite imagery • Analysis realized or approaches adopted: geospatial analysis • Information produced using GEOINT: assessing of the period of the violation	

CASE NO. 20  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Hungary
	Contributor	Duna-Ipoly National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Park ranger reports

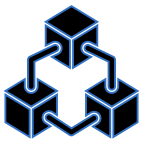
CASE OVERVIEW	
River Danube contamination in the region of Szigetszentmiklós due to oil spill of 6500 liters.	
Type of event	Incident (unauthorized and/or non-compliant activities)
Reference date of the event	14/12/2020 to approximately 28/02/2021
Site interested by the event	Protected species; Natural habitats; Surface water
Natural resources	Natural habitats; soil; water

APPLICATION OF GEOSPATIAL INTELLIGENCE	
UAS surveys were used to detect the damaged area. Spatially explicit database of vegetation maps, protected plant and animal species collected during surveys prior the incident was used to detect which species were potentially polluted or killed.	
Procedure requested by	Duna-Ipoly National Park Directorate
Procedure realized by	Not available

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal and administrative procedure
Stage of procedure	Not available

Additional information	Not available
TECHNICAL SPECIFICATIONS	
Data used	UAV imagery was used to detect the damaged area; spatially explicit database of vegetation maps[8]; protected plant and animal species collected during surveys
Type of analysis	Qualitative and quantitative
Methodological approach	Geostatistical analysis. GIS database to detect how many and what kind of species were polluted or killed based on earlier surveys of protected plant and animal species and vegetation maps
Algorithms used	QGIS software
Uncertainty estimate	Not available
Produced information	For the protected species: number of damaged individuals. For natural habitats: assess the extent of damaged area. For superficial water: assess the extent of the damaged water body.
KEY POINTS	
• Case type: individuation of the proofs of the environmental damage • Event type: incident (unauthorized and/or non-compliant activities) • Type of procedure: legal and administrative • Source of data used: UAS surveys, vegetation maps from databases, in-situ survey (protected plant and animal species) • Analysis realized or approaches adopted: geostatistical analysis • Information produced using GEOINT: quantitative estimate of area interested by the impacts, the number of affected protected species individuals, and the extension of the water body affected by the spill	

[8] https://doi.org/10.18426/obm.23mj4em6bca0

CASE NO. 21  GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Balaton-felvidéki National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Park ranger reports

CASE OVERVIEW	
Grassland damage caused by forestry machinery, with endangerment of protected species.	
Type of event	Violation (unauthorized and/or non-compliant activities)
Reference date of the event	20/12/2022 - 31/12/2022
Site interested by the event	Natural area
Natural resources	Protected species; Natural habitats
APPLICATION OF GEOSPATIAL INTELLIGENCE	
Copernicus Sentinel-2 satellite images were used to determine the period of the event, and to estimate the damaged area. The area of damage was surveyed by UAS, to produce an orthomosaic.	
Procedure requested by	Balaton-felvidéki National Park Directorate
Procedure realized by	Not available
PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case (80. § (1) b) Law No. LIII of 1996 on Nature Conservation)
Type of procedure	Administrative
Stage of procedure	Not available
Additional information	Not available
TECHNICAL SPECIFICATIONS	
Data used	Field data collected in specific surveys realized after the damage

	event; satellite imagery; UAV imagery
Type of analysis	Geostatistical analysis
Methodological approach	Copernicus Sentinel-2 MSI satellite imagery (free and open access distribution policy) was first used to determine the period of the event, and to estimate the damaged area. The area of damage was surveyed by UAS, to produce an orthomosaic. Orthomosaic was used to calculate the spatial extent of the damage in QGIS software. The extent of the damaged area was compared with the biotic database of the Directorate. Due to the large area covered and the difficult terrain conditions, the traditional use of field reconnaissance and handheld GPS was not appropriate. Satellite acquisitions were used to successfully establish the beginning of the event, thanks to Copernicus Sentinel satellites revisit time. UAS surveys and geostatistical analysis can be repeated. Comparison between the status of the natural resource in an area with negative impacts due to the damaging occurrence and a non-impacted area.
Algorithms used	QGIS software
Uncertainty estimate	Not available
Produced information	Assess the extent of damaged area

KEY POINTS

- Case type: general assessment of the event
- Event type: violation (unauthorized and/or non-compliant activities)
- Type of procedure: administrative
- Source of data used: open-access satellite imagery and UAS surveys
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: quantitative estimate of area interested by the impacts and assessing of the period of the violation

CASE NO. 22  INDIVIDUATION OF THE PROOFS OF THE ENVIRONMENTAL DAMAGE	Country	Hungary
	Contributor	Balaton-felvidéki National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Authority inspection, reports

CASE OVERVIEW	
The protected population of the Hungarian iris (Iris variegata), consisting of several hundred plants, was damaged and destroyed during sand mining operations in a sand mining site.	
Type of event	Incident (unauthorized and/or non-compliant activities - mining)
Reference date of the event	July 2021
Site interested by the event	Natural area; sand mine
Natural resources	Protected plant species; Natural habitats

APPLICATION OF GEOSPATIAL INTELLIGENCE	
During a joint on-site inspection in the area affected by the operations, the number of shoots of the protected Hungarian iris was recorded using a GPS device. Extent of the area affected by illegal activities was calculated based on recorded geolocated points.	
Procedure requested by	Balaton-felvidéki National Park Directorate
Procedure realized by	Not available

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	ELD case
Type of procedure	Legal procedures
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	Field data collected in specific surveys realized after the damage event, geolocated using a GPS device
Type of analysis	Quantitative
Methodological approach	The extent of the damaged area was assessed using geostatistical analysis from geolocation of field surveys and compared with the biotic database of the Directorate
Algorithms used	QGIS software
Uncertainty estimate	Not available
Produced information	Assessment of the number of affected individuals and the extent of damaged area

KEY POINTS

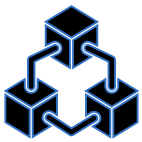
- Case type: individuation of the proofs of the environmental damage
- Event type: incident (unauthorized and/or non-compliant activities - mining)
- Type of procedure: legal
- Source of data used: geolocated surveys
- Analysis realized or approaches adopted: geolocation of the biotic database based on the data from GPS survey
- Information produced using GEOINT: quantitative estimate of area interested by the impacts and assessment of the number of protected species affected individuals

CASE NO. 23 GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Kiskunsági National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Ranger service log (via report to the authority)
CASE OVERVIEW		
Changes in protected natural area, damaging a Natura 2000 area.		
Type of event	Violation (unauthorized and/or non-compliant activities)	
Reference date of the event	2023	
Site interested by the event	Protected Natura 2000 site	
Natural resources	Protected species; Natural habitats	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Use of time series of satellite images available in Google Earth to determine the size of the damaged area. Field measurements using high-precision GPS device.		
Procedure requested by	Kiskunsági National Park Directorate	
Procedure realized by	Not available	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (Law No. LIII of 1996 on Nature Conservation and Decree No. 275 of 2004 (X. 8.) of the Government on nature conservation areas of European Community importance)	
Type of procedure	Legal	
Stage of procedure	Not available	
Additional information	Not available	

TECHNICAL SPECIFICATIONS	
Data used	The use time series of satellite images available in Google Earth to determine the size of the damaged area. Field data collected in specific surveys using high-precision GPS device
Type of analysis	Qualitative and quantitative
Methodological approach	Use of Google Earth space photos to present the before-after situation, use of high-precision GPS to delineate the damaged area, ArcMap software for data visualization
Algorithms used	ArcGIS software
Uncertainty estimate	Not available
Produced information	Assess the size of the damaged area

KEY POINTS

- Case type: general assessment of the event
- Event type: violation (unauthorized and/or non-compliant activities)
- Type of procedure: legal
- Source of data used: orthomosaics available in Google Earth, geolocated surveys
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: estimate of the damaged area

CASE NO. 24  GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Bükk National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Database, ranger service report to the authority
CASE OVERVIEW		
Illegal, unauthorized ploughing in a Nature 2000 site.		
Type of event	Violation (unauthorized and/or non-compliant activities)	
Reference date of the event	2020	
Site interested by the event	Natural area	
Natural resources	Natural habitats; Protected species	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Official database, GPS data collected on site in relation with species identification and location on site.		
Procedure requested by	Bükk National Park Directorate	
Procedure realized by	Not available	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (Decree (269/2007), Decree13/2001 and Law No. LIII of 1996 on Nature Conservation)	
Type of procedure	Legal	
Stage of procedure	Not available	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Official database; field data collected in specific surveys realized	

	after the damage event using a GPS device for geolocation
Type of analysis	Qualitative and quantitative
Methodological approach	Comparison between the status of the natural resource in an area with negative impacts due to the damaging occurrence and a non-impacted area
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	For the protected plant species: number of damaged individuals. For natural habitats: extension of damaged area. Impacts on animal species was relevant but could not be verified.
KEY POINTS	
• Case type: general assessment of the event • Event type: violation (unauthorized and/or non-compliant activities) • Type of procedure: legal • Source of data used: geolocated surveys • Analysis realized or approaches adopted: geostatistical analysis • Information produced using GEOINT: quantitative estimate of area interested by the impacts and assessment of number of protected species affected	

CASE NO. 25 GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Bükk National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Database, ranger service report to the authority

CASE OVERVIEW	
Human-caused fire on a Nature 2000 site and protected meadow.	
Type of event	Incident (fire)
Reference date of the event	2022
Site interested by the event	Natural area
Natural resources	Protected species; Natural habitats; Groundwater (since it is a carsic area, there is high probability that the groundwater was also affected)

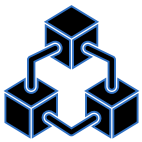
APPLICATION OF GEOSPATIAL INTELLIGENCE	
Official database, GPS data collected on site in relation with species identification and location on site.	
Procedure requested by	Bükk National Park Directorate
Procedure realized by	Not available

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case (Law No. LIII of 1996 on Nature Conservation, Decree 269/2007 decree)
Type of procedure	Legal
Stage of procedure	Not available
Additional information	Not available

TECHNICAL SPECIFICATIONS	
Data used	Database; GPS data collected on site for exact geolocation of the species damaged; UAV imagery
Type of analysis	Qualitative
Methodological approach	Comparison between data from surveys and the threshold values defined by the law
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Geolocation of damages species

KEY POINTS

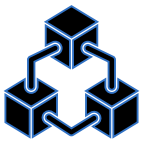
- Case type: general assessment of the event
- Event type: incident (fire)
- Type of procedure: legal
- Source of data used: geolocated surveys and UAS survey
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: geolocation of damages species

CASE NO. 26  GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Bükk National Park Directorate
	Role of contributor	Nature conservation management authority
	Source of information	Database, ranger service report to the authority
CASE OVERVIEW		
Illegal logging.		
Type of event	Violation (unauthorized and/or non-compliant activities - logging)	
Reference date of the event	2021	
Site interested by the event	Natural area	
Natural resources	Protected species; Natural habitats	
APPLICATION OF GEOSPATIAL INTELLIGENCE		
Official database, GPS data collected on site in relation with species identification and location on site.		
Procedure requested by	Bükk National Park Directorate	
Procedure realized by	Not available	
PROCEDURAL AND LEGAL SPECIFICATIONS		
Type of case	Non-ELD case (Law No. LIII of 1996 on Nature Conservation)	
Type of procedure	Legal	
Stage of procedure	Not available	
Additional information	Not available	
TECHNICAL SPECIFICATIONS		
Data used	Database; Field data collected in specific surveys realized after the damage event with exact geolocation of the species damaged using GPS device	

Type of analysis	Qualitative
Methodological approach	Not available
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Location of damages species

KEY POINTS

- Case type: general assessment of the event
- Event type: violation (unauthorized and/or non-compliant activities - logging)
- Type of procedure: legal
- Source of data used: in-situ surveys using a GPS device for geolocation
- Analysis realized or approaches adopted: geostatistical analysis
- Information produced using GEOINT: geolocation of damages species

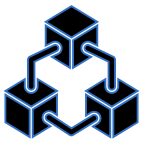
CASE NO. 27  GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	Government Office of Csongrád-Csanád
	Role of contributor	Government Office
	Source of information	Reports by non-institutional experts

CASE OVERVIEW	
During the construction period of a new water reservoir, some specimen of protected plant species was reported to be likely affected by transport vehicles.	
Type of event	Violation (unauthorized and/or non-compliant activities)
Reference date of the event	November 2021
Site interested by the event	Natural area
Natural resources	Protected species
APPLICATION OF GEOSPATIAL INTELLIGENCE	
Comparison between pre-recorded geolocated data of the plant specimens (recorded during the previous spring) and the transport routes, both recorded by GPS devices.	
Procedure requested by	Government Office
Procedure realized by	Non-institutional experts
PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case (Law No. LIII of 1996 on Nature Conservation)
Type of procedure	Legal procedure
Stage of procedure	Not available
Additional information	During the construction period of a new water reservoir, some specimens of protected plant species were reported to be likely affected by transport vehicles

TECHNICAL SPECIFICATIONS	
Data used	Field data collected in specific surveys realized after the damage event
Type of analysis	Quantitative
Methodological approach	The authority used pre-recorded geolocated data of the plant specimens (recorded during the previous spring) overlapping the transport routes, also recorded by GPS devices.
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Individuation of the areas interested by the vehicles transit

KEY POINTS

- Case type: general assessment of the event
- Event type: violation (unauthorized and/or non-compliant activities)
- Type of procedure: legal
- Provider of geospatial techniques: non-institutional experts
- Source of data used: vegetational in-situ surveys
- Information produced using GEOINT: estimate of the area interested by the vehicles transit

CASE NO. 28  GENERAL ASSESSMENT OF THE EVENT	Country	Hungary
	Contributor	General Prosecutor's Office of Hungary
	Role of contributor	Prosecution Service
	Source of information	Report

CASE OVERVIEW	
The offender had accumulated a significant amount of waste (tyres) without a waste management permit at a waste treatment site in the countryside, which posed an environmental risk.	
Type of event	Violation (non-compliant waste management)
Reference date of the event	2016 (first evidence)
Site interested by the event	Waste management site
Natural resources	Soil

APPLICATION OF GEOSPATIAL INTELLIGENCE	
Satellite images time series available from Google Earth and UAV imagery taken by the whistleblower to demonstrate that waste disposal was increasing in time.	
Procedure requested by	General Prosecutor's Office of Hungary
Procedure realized by	General Prosecutor's Office of Hungary

PROCEDURAL AND LEGAL SPECIFICATIONS	
Type of case	Non-ELD case; Act C of 2012 on Criminal code
Type of procedure	Legal procedures
Stage of procedure	Ongoing
Additional information	The ongoing prosecution was launched in 2022, following other official proceedings

TECHNICAL SPECIFICATIONS

Data used	Orthomosaics available from Google Earth and UAV imagery
Type of analysis	Qualitative
Methodological approach	Time series analysis
Algorithms used	Not available
Uncertainty estimate	Not available
Produced information	Follow up of the waste volume

KEY POINTS

- Case type: general assessment of the event
- Event type: violation (non-compliant waste management)
- Type of procedure: legal
- Provider of geospatial techniques: General Prosecutor's Office of Hungary
- Source of data used: Google Earth images and UAS survey
- Information produced using GEOINT: qualitative follow up of the waste volume

4.2. Overview of reported cases

The use of geospatial intelligence techniques in the context of environmental damage covers different applications:

- the general assessment of the event: for a general a view of the event (e.g. geolocation of the event, individuation of the areas where to study the impacts);
- the individuation of the proofs of the environmental damage: for the quantification of the environmental damage (e.g. estimation of the damaged areas or of the period of violation);
- support in environmental damage remediation planning (e.g. quantify the amount of materials to restore a damaged area).

The reported cases reveal a cross-cutting application of the geospatial intelligence in the context of the environmental damage (Figure 7), with a prevalence of cases where the geospatial intelligence is used to support the general assessment of the event.

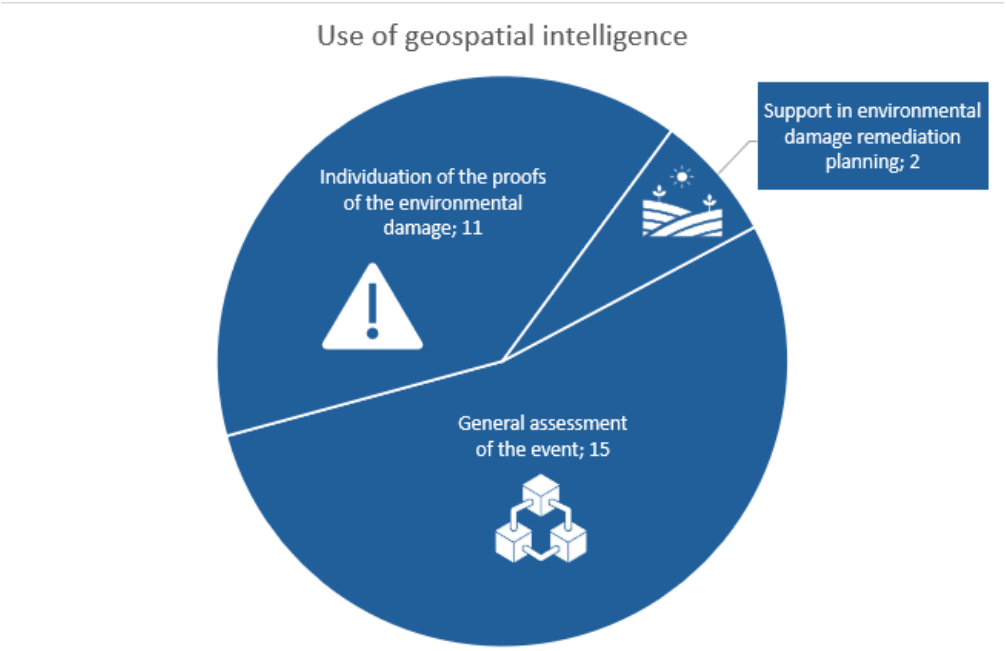


Figure 7. Application fields of geospatial intelligence in the context of the environmental damage

Based on the information collected in the datasheets, it is possible to underline some relevant aspects. Considering the objectives of the GIEDA project, which focuses on the use of geospatial intelligence, two main elements are analysed:

- the source of geospatial data;
- the information produced using geospatial intelligence.

The source of geospatial data

In the examined cases the geospatial data come from different sources, that can be divided in three main categories:

- in-situ surveys (for geolocation or to detect specific aspects, e.g. bathymetry, plant species);
- remote sensing data (satellite; aerial; UAV imagery);
- Repositories (Google products, e.g. Google Earth, Google Street View; other specific databases, for example for vegetation).

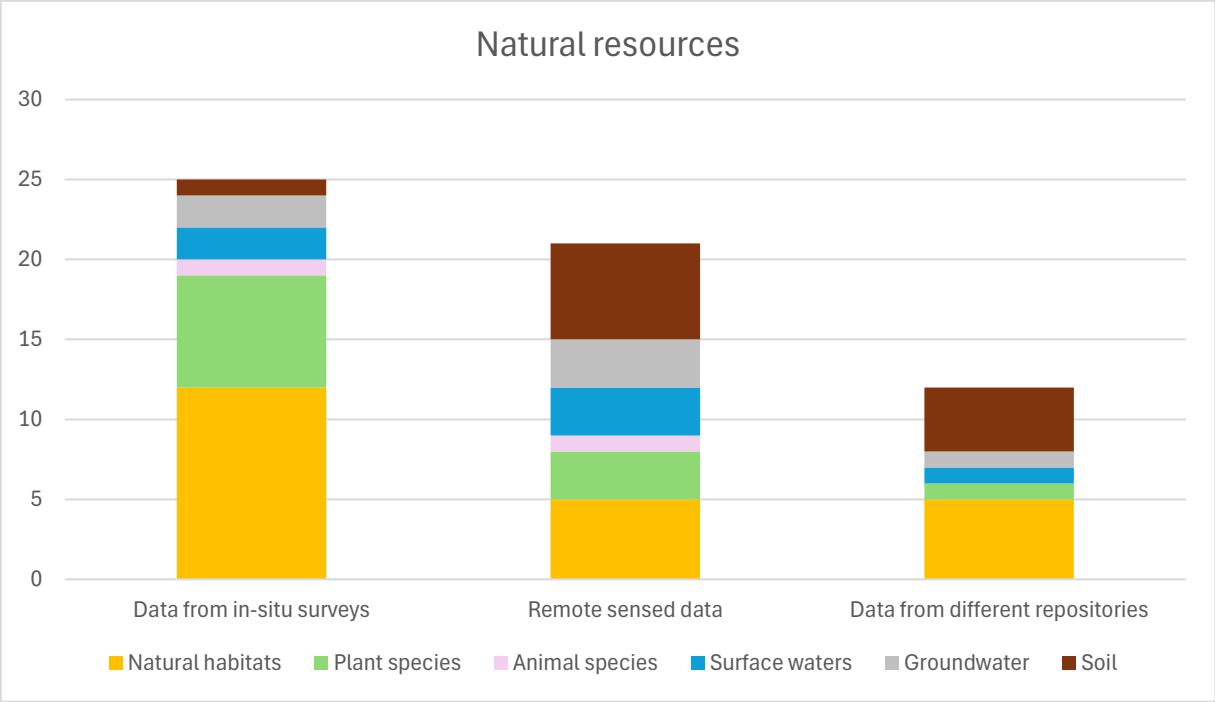
Table 2. The source of geospatial data for the cases collected in the datasheet

CASE NO.	TYPE OF EVENT	IN SITU SURVEYS DATA		REMOTE SENSING DATA			REPOSITORIES	
		GEOLOCATION	OTHER	SATELLITE	AERIAL	UAV (DRONE)	GOOGLE PRODUCTS	OTHER DATABASES
1	V		✓			✓		
2	V		✓					
3	V			✓				
4	V		✓					
5	I			✓				
6	V			✓		✓		
7	V			✓				
8	V			✓	✓		✓	
9	V I			✓				
10	V				✓		✓	
11	V					✓		
12	V	✓		✓				
13	V	✓						
14	I	✓		✓				
15	V					✓		
16	V						✓	
17	V	✓					✓	
18	V	✓			✓			✓
19	I			✓				
20	I		✓			✓		✓
21	V			✓		✓		
22	I	✓						
23	V	✓					✓	
24	V	✓						
25	I	✓				✓		
26	V	✓						
27	V	✓						
28	V					✓	✓	

V: violation (grey color); I: incident (red color)

As it is possible to observe in Table 2, data come from all the different sources, without a strong prevalence. For the cases concerning incidents, remote sensing data are mostly used, this is probably linked to the need of a rapid response also without reaching the site.

The examined cases involve all natural resources covered by ELD. In particular, it is possible to observe in Figure 8 that that in-situ surveys are mainly used when natural habitats or plant species are concerned, because in many cases a GPS geolocation is required, and specific surveys are carried out (e.g. forestry or botanical). For the cases concerning the soil or groundwater there is a larger usage of remote sensed data.



* Total number of records are greater than the total number of the cases, because in a single cases many natural resources can be involved

Figure 8. Natural resources involved in the cases collected in the datasheet

The information produced using geospatial intelligence

The statistics on reported cases allowed to individuate the type of information that is produced by the use of geospatial intelligence (Figure 9), which is mainly related to estimate the extent of the area affected by the event, followed by the estimation of waste volume.

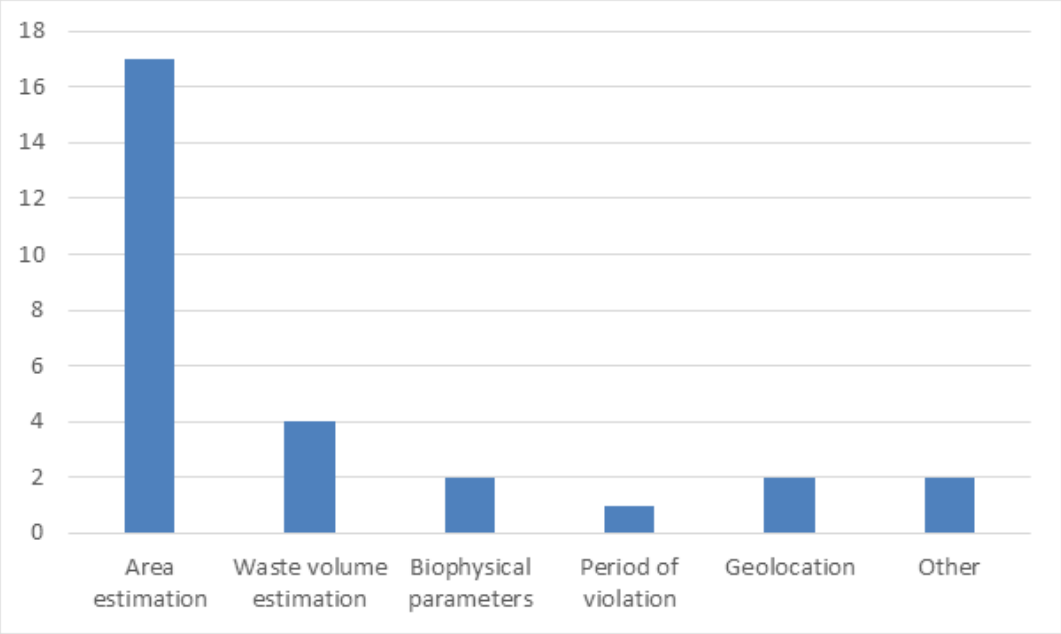


Figure 9. Distribution of the information produced using geospatial intelligence

The estimation of areas is mainly produced in cases concerning “unauthorized and/or non-compliant activites” (Figure 10), for which there is the need to calculate areas affected by various types of impacts. The waste volume estimation is generated, as expected, in the cases concerning “non-compliant waste management”.

Figure 10. Activity field for the cases where geospatial intelligence is applied to obtain area estimation r waste volume estimation

Relation between the geospatial data used and the produced information

As it is possible to observe in Figure 11, examined the case of areas estimation that is the information mainly produced using the geospatial intelligence, data used come from various sources, with a light prevalence of in-situ surveys. For the waste volume estimation, the remote sensed data are the mainly used, with a large usage of UAV imagery (i.e. drones surveys).

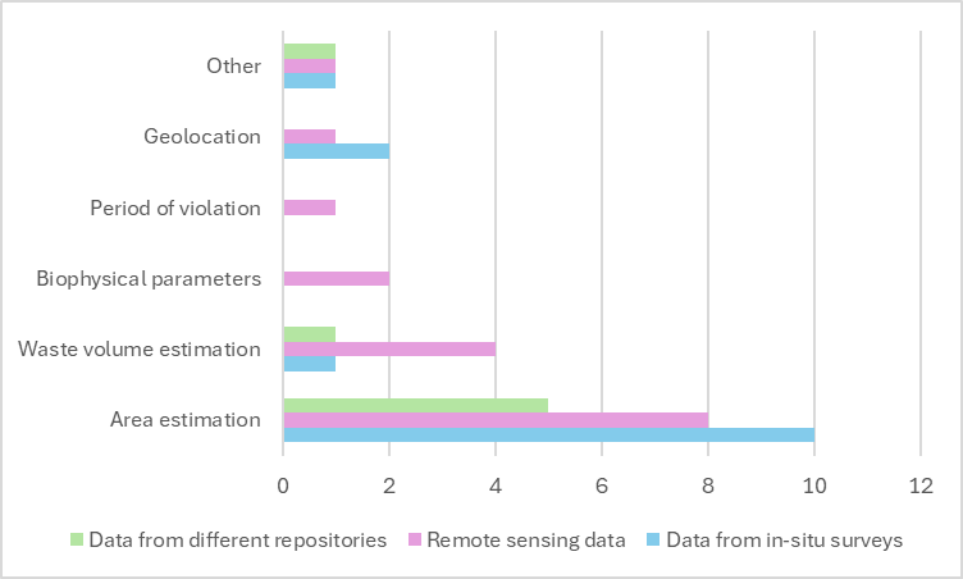


Figure 11. Information produced from the different geospatial data

While various technical approaches were reported, the most used approach to produce information using geospatial intelligence is the geostatistical analysis (Figure 12).

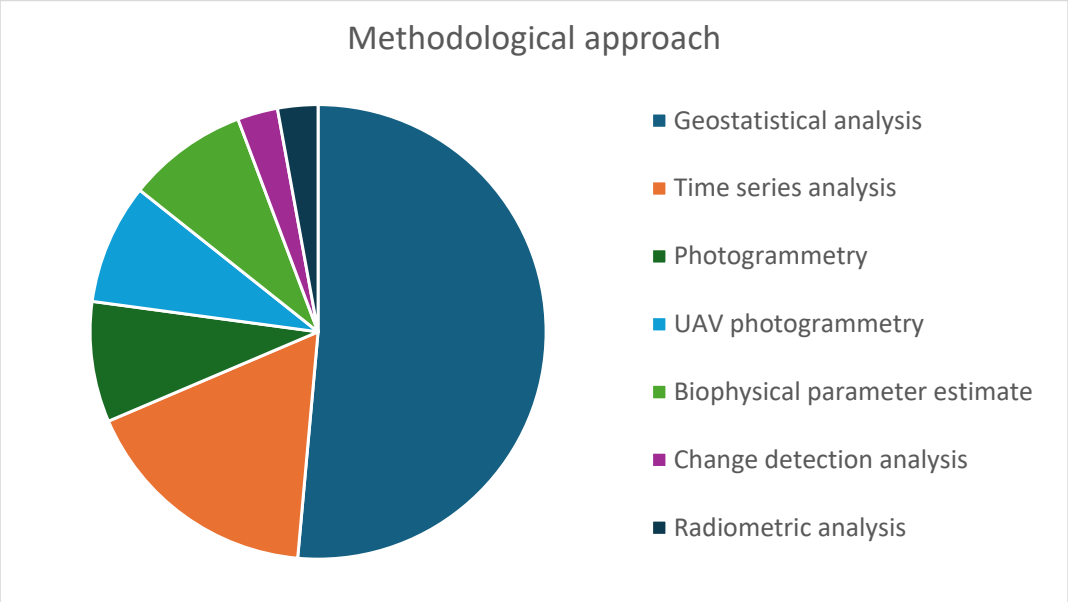


Figure 12. Methodological approach used to analyse geospatial data

5. DISCUSSION

5.1. Main outcomes

According to the project objectives, the following goals were achieved:

- share knowledge, between the project members, by reporting on demonstrating real cases, showing geospatial intelligence ability to produce relevant qualitative and quantitative information for the general assessment of the case, for identifying proofs of environmental damage, for support in environmental damage remediation planning, with the aim of increase agencies and regulators capability;

- begin to process of raising the awareness of prosecutors and judges about appropriate and reliable product available from geospatial intelligence thanks to the information reported for real cases.

5.2. Challenges: difficulties experienced

The main difficulties encountered during the implementation of the project actions are reported in this section.

- Identify cases was a challenging task. There are no specific official databases of environmental damage sentences, both at European level and national scale. Some of the existing databases of sentences have restricted access and could not be queried.

- It was difficult to obtain technical information related to the use of geospatial intelligence, even at a poor level of detail, from the many available reports or from the sentences. When technical information was not contained in official documents (e.g., judgments), a direct contact with the various parties involved in the environmental damage assessment process (e.g. investigators, environmental agencies, prosecutors) was needed to get technical details on single cases (where applicable).

5.3. General considerations: discussion, lessons learned, limitations and implications

The GIEDA project allowed to identify and review methods enabled by geospatial intelligence to support better detection, characterization and ascertainment of environmental damage. Results should inform the definition of requirements for usable information generated using geospatial intelligence technology, identifying gaps and supporting environmental investigations of violation of environmental laws.
A total of 28 real cases collected using different approaches (e.g. surveys, database query, reporting review) were reported, with relevant information about the use of geospatial intelligence. The reported cases are a non-exhaustive list of all actual cases in Europe, where geospatial intelligence has been used for the general assessment of the case, to identify proofs of environmental damage, for support in environmental damage remediation planning.

In order to increase the number of responses, the questionnaire-based survey did not ask for specific information on sentencing (reference number, status). Consequently, the sentence is unknown. In other cases, sentences are not yet concluded (inquiry stage). Questionnaire respondents could be inspectors that only known cases because e.g. of ascertainment requests, and do not know about which is the specific sentence. Generally speaking, the point of contact of the questionnaire respondents was not acquired, with consequent repercussions on possibilities to perform more in-depth analysis on the recorded cases.
It is important to underline that for some reported real cases, the collected information is deeper than the information available in the specified source of information (e.g. reports, questionnaire responses). This occurs especially for the technical elements, and it has been possible through the direct knowledge of some real cases.
Real cases related to non-compliant waste management resulted the most reported for the use of geospatial intelligence technology. Remote sensing data (including the use of drones) and geolocation acquired using GPS devices are the most source of information used. Geostatistical analysis resulted the most used methodological approach. The estimation of the extent of the area affected by the event is the most produced quantitative information. Such results should allow to identify the priority areas to improve the integration of Earth observation capabilities in geospatial intelligence workflows and protocols for environmental damage investigations.
Many cases reported the use of open-access satellite imagery to generate the evidence, which can play a key role in proceedings. Considering that the defendant (i.e. the party being sued or accused) may dispute the use of restricted-access datasets, the use of open-access satellite imagery and free software tools should allow replicability of evidence extraction based on geospatial intelligence. Free, full and open data policy has been adopted by the EU for the Copernicus programme, providing a wide range of satellite acquisitions, which foresees access by all users to the Copernicus Sentinels core products. Diversely, other source of information (e.g. provided by Google services), may not guarantee the availability of the same information in the future and thereby may not be sufficient without additional accompanying information. In a sentence related to a quarry, it was noted that the use of orthomosaics from Google Earth has been considered acceptable as it is supported by visual and photographic surveys conducted at the site of interest by public officials, as well as by orthomosaics available in public databases.
With respect to the technical elements resulted from the reported cases, satellite remote sensing may have some limitations, related for example to revisit time, spatial resolution or persistent cloud cover for the optical multispectral sensor acquisitions. No relevant information can be provided regarding the admissibility of geospatial-based evidence in court, or regarding the use of specific algorithms for the analysis of data. The same applies for the uncertainty estimates, associated to the quantitative estimate, that were generated and provided for some reported real cases.
Long time frame elapses between infringements and sentences. The geospatial intelligence technology is evolving much faster. This aspect may affect the suitability of the reported techniques and analysis tools, which may already be superseded. In fact, the last years have witnessed transformative developments in Earth observation, particularly from satellite-based platforms, leading to data streams of increased spatial, spectral, and temporal detail. Moreover, the recent advances in UAS technology, integrated with satellite-

derived data and artificial intelligence, may require the need to present examples of good practice using updated technologies. Another concern is related to the ELD, that does not explicitly foresee the use of geospatial intelligence or Copernicus services.
The project results did not allow to precisely define technical and legal requirements, unlike expected. Therefore, the definition of guidelines related to organizational technical aspects and issues to be implemented, aimed at fostering the use of geospatial intelligence by environmental agencies and inspectorates, it is still far from being achieved. An in-depth analysis better focused on technical and legal aspects, should be carried out using different approaches.
The process of developing tools and guidelines for the use of evidence of environmental damage obtained by geospatial intelligence for its appropriate use, meeting the requirements for their use in court, has made advancements, although it still needs further actions to be put in place. The GIEDA project provided a baseline of needs to setup action aimed at improving agencies capacity

6. Follow-up

Considering the actions that would significantly promote the use of geospatial intelligence to investigate and ascertain eco-criminal acts across EU (see paragraph 1.1), the process of developing tools and guidelines still need further development in the future.
Based on the results obtained from the GIEDA project, specific objectives to be addressed in the future are:

- extend the reporting to real cases under Environmental Crime Directive;
- perform in-depth analysis of technical and legal aspects related to real cases;
- raise the awareness of prosecutors and judges about appropriate and reliable product available from geospatial intelligence in the context of multidisciplinary evidence collection to assure environmental compliance;
- perform requirements analysis to identify necessary information for use in the courts that can be generated by geospatial intelligence;
- provide a baseline of needs to setup action aimed at improving environmental agencies and inspectors capability;
- train environmental agency and competent authorities in the use geospatial intelligence technology;
- foster institutional use and the legal application of technologies for environmental analysis, making regulations more efficient.

Annexes

Annex I. Short questionnaire form

IMPEL GIEDA project - Short questionnaire

Geospatial Intelligence for Environmental Damage Assessment (GIEDA)
Short questionnaire to identify:

- national and local regulations that implement Environmental Liability Directive 2004/35/EC
- national Databases of legal environmental judgment
- specific cases of judgments for environmental damage that have used information produced by Geospatial intelligence and/or remote sensing as evidence in court

* Required

1. Country *

2. Organization

3. Which are national and local regulations that implement Environmental Liability Directive 2004/35/EC?

4. Are there databases of legal environmental judgments in your country? *

- ◯ Yes
- ◯ No
- ◯ Don't know

5. If yes, specify the name of existing databases, access options, and point of contact for database access.

6. To your knowledge, are there specific cases of judgments for environmental damage that have used information produced by Geospatial intelligence and/or remote sensing as evidence in court?

Annex II. Set of keywords used for databases query

- Group: Type of event

- illegal building
- illegal construction
- illegal constructions
- manure spreading
- manure dumping
- manure
- illegal logging
- illegal vegetation cutting
- destruction of vegetation cover
- destruction of vegetation cover
- rejection of wastewater into the soil/river/sea
- oil spills
- marine litter
- marine waste
- waste disposal (including end-of-life vehicles)
- waste dumping
- waste deposits
- waste deposit
- excavations and landfills

- Group: Geospatial intelligence techniques

- Drone
- Satellite Image
- Satellite Images
- Geospatial

Annex III. Extended questionnaire form

IMPEL GIEDA project - Survey

The IMPEL Geospatial Intelligence for Environmental Damage Assessment (GIEDA) project aims to contribute to information needs related to illegal activities affecting environmental matrices by reporting effective methodological approaches using geospatial intelligence to investigate and ascertain environmental damage, based on the use of earth observation and geostatistical analysis.

This survey aims to identify real cases of environmental legal judgments in which geospatial intelligence approaches have been used to produce evidence and support the assessment and ascertainment of environmental damage.
The geospatial intelligence knowledge questions aim to initiate the process of identifying the legal aspects and requirements relevant to the use of information produced by geospatial intelligence in the courts.

* Required

Section A

1. Country *

2. Organization *

3. Role (e.g. competent authority for the environmental damage, investigators, judges, prosecutor, etc.) *

4. In the context of environmental damage (ELD or non-ELD cases) the geospatial intelligence (e.g. use of remote sensing data, geostatistical analysis) can be applied for different purposes:
   - preliminary evaluation of damaging occurrence (e.g. description of the territorial context)
   - individuation of the proofs of environmental damage
   - definition of the remediation measurements.

   Do you know about any cases of environmental violations for which geospatial intelligence has been used to assess environmental damage under the Environmental Liability Directive 2004/35/EC (ELD cases), or other legislation (non-ELD cases)? *

   - ◯ Yes
   - ◯ No

Section B

5. Specify the number of cases and the reference period *

(e.g. 2 cases in the period 2020-2023)

Section B1

Reported case: 1

6. Which is the source of the information about the case you are describing? *
(e.g. database, repository, reports. Source reference or web link is highly appreciated)

7. Synthetic description of the case *
(e.g. contamination of a river due to non-compliant discharges from an industrial plant)

8. Type of environmental damage *

- ◯ Incident
- ◯ Violation
- ◯ Other

9. Reference date of the event *
(i.e. the date for an incident or the reference period for violations)

10. Regulatory scope of the case *

- ◯ ELD case
- ◯ Non-ELD case

11. For Non-ELD case, specify the relevant legislation *

12. Type of procedure under the case is inquired *

- ◯ Legal
- ◯ No legal
- ◯ Both

13. Activity that determined the environmental damage *

- [ ] Waste management
- [ ] Disposal of contaminants in water
- [ ] Disposal of contaminant on soil
- [ ] Omitted reparation of contaminated areas
- [ ] Impacts on vegetal species
- [ ] Impacts on animal species
- [ ] Mining
- [ ] Fire
- [ ] Illegal buildings
- [ ] Other

14. Site interested by the environmental damage event *

- ◯ Plant for the waste management
- ◯ Industrial plant
- ◯ Purification plant
- ◯ Transportations (e.g. shipping incidents)
- ◯ Natural area
- ◯ Quarry
- ◯ Livestock
- ◯ Manufacturing sector
- ◯ Other

15. Natural resources damaged *

(ref. Article 2 – Directive 2004/56/EC)

- [ ] Protected species
- [ ] Natural habitat
- [ ] Surface water
- [ ] Groundwater
- [ ] Land
- [ ] Air
- [ ] Other

16. Have geospatial intelligence techniques been used to support general assessment of the event? *

(e.g. description and characterization of the territorial context)

- ◯ Yes
- ◯ No

17. Provide a synthetic description of the usage of the geospatial techniques to support the general assessment of the event *

(e.g. description and characterization of the territorial context)

18. Have geospatial intelligence techniques been used to support the assessment of environmental damage remediation? *

(e.g. definition of the measures or monitor their follow-up)

- ◯ Yes
- ◯ No

19. Synthetic description of the usage of the geospatial techniques to support the assessment of environmental damage remediation *

Provide the following information about entity of the damaged natural resources to be repaired:

- For the protected species: number of damaged individuals
- For natural habitat: extension of damaged area
- For superficial water: extension/length of the damaged water body
- For underground water: extension of the damaged water body
- For land: extension of damaged area

20. Have geospatial intelligence techniques been used to support the individuation of the proofs of environmental damage? *

- ◯ Yes
- ◯ No

21. Provide a synthetic description of the usage of the geospatial techniques to support the individuation of the proofs of environmental damage *

22. Data used to analyse the status of the natural resources *

- ☐ Data from competent authority: to be specified (e.g. ecological/chemical status under Directive 2000/60/EC)
- ☐ Field data collected in specific surveys realized after the damage event
- ☐ Remote sensing data
- ☐ Other

23. Methods used in the evaluation of environmental damage *

- [ ] Comparison between the ante/post status of the natural resource (e.g. the chemical status under Directive 2000/60/EE)
- [ ] Statistical analysis
- [ ] Geostatistical analysis
- [ ] Comparison between data from surveys and the threshold values defined by the law
- [ ] Comparison between the status of the natural resource in an area with negative impacts due to the damaging occurrence and a non-impacted area
- [ ] Usage of specific software for the evaluation of environmental damage
- [ ] None
- [ ] Other

24. Do you know about any other case of environmental violations for which geospatial intelligence has been used to assess environmental damage under the Environmental Liability Directive 2004/35/EC (ELD cases), or other legislation (non-ELD cases)? *

- ◯ Yes
- ◯ No

Section B2

Reported case: 2

25. Which is the source of the information about the case you are describing? *

(e.g. database, repository, reports)

26. Synthetic description of the case *

(e.g. contamination of a river due to non-compliant discharges from an industrial plant)

27. Type of environmental damage *

- ◯ Incident
- ◯ Violation
- ◯ Other

28. Reference date of the event *

(i.e. the date for an incident or the reference period for violations)

29. Regulatory scope of the case *

- ◯ ELD case
- ◯ Non-ELD case

30. For Non-ELD case, specify the relevant legislation *

31. Type of procedure under the case is inquired *

- ◯ Legal
- ◯ No legal
- ◯ Both

32. Activity that determined the environmental damage *

- [ ] Waste management
- [ ] Disposal of contaminants in water
- [ ] Disposal of contaminant on soil
- [ ] Omitted reparation of contaminated areas
- [ ] Impacts on vegetal species
- [ ] Impacts on animal species
- [ ] Mining
- [ ] Fire
- [ ] Illegal buildings
- [ ] Other

33. Site interested by the environmental damage event *

- ◯ Plant for the waste management
- ◯ Industrial plant
- ◯ Purification plant
- ◯ Transportations (e.g. shipping incidents)
- ◯ Natural area
- ◯ Quarry
- ◯ Livestock
- ◯ Manufacturing sector
- ◯ Other

34. Natural resources damaged *

(ref. Article 2 – Directive 2004/56/EC)

- [ ] Protected species
- [ ] Natural habitat
- [ ] Surface water
- [ ] Groundwater
- [ ] Land
- [ ] Air
- [ ] Other

35. Have geospatial intelligence techniques been used to support general assessment of the event? *

(e.g. description and characterization of the territorial context)

- ◯ Yes
- ◯ No

36. Provide a synthetic description of the usage of the geospatial techniques to support the general assessment of the event *

(e.g. description and characterization of the territorial context)

37. Have geospatial intelligence techniques been used to support the assessment of environmental damage remediation? *

(e.g. definition of the measures or monitor their follow-up)

- ◯ Yes
- ◯ No

38. Synthetic description of the usage of the geospatial techniques to support the assessment of environmental damage remediation *

Provide the following information about entity of the damaged natural resources to be repaired:

- For the protected species: number of damaged individuals
- For natural habitat: extension of damaged area
- For superficial water: extension/length of the damaged water body
- For underground water: extension of the damaged water body
- For land: extension of damaged area

39. Have geospatial intelligence techniques been used to support the individuation of the proofs of environmental damage? *

- ◯ Yes
- ◯ No

40. Provide a synthetic description of the usage of the geospatial techniques to support the individuation of the proofs of environmental damage *

41. Data used to analyse the status of the natural resources *

- ☐ Data from competent authority: to be specified (e.g. ecological/chemical status under Directive 2000/60/EC)
- ☐ Field data collected in specific surveys realized after the damage event
- ☐ Remote sensing data
- ☐ Other

42. Methods used in the evaluation of environmental damage *

- [ ] Comparison between the ante/post status of the natural resource (e.g. the chemical status under Directive 2000/60/EE)
- [ ] Statistical analysis
- [ ] Geostatistical analysis
- [ ] Comparison between data from surveys and the threshold values defined by the law
- [ ] Comparison between the status of the natural resource in an area with negative impacts due to the damaging occurrence and a non-impacted area
- [ ] Usage of specific software for the evaluation of environmental damage
- [ ] None
- [ ] Other

43. Do you know about any other case of environmental violations for which geospatial intelligence has been used to assess environmental damage under the Environmental Liability Directive 2004/35/EC (ELD cases), or other legislation (non-ELD cases)? *

- ◯ Yes
- ◯ No

Section B3

Reported case: 3

44. Which is the source of the information about the case you are describing? *

(e.g. database, repository, reports)

45. Synthetic description of the case *

(e.g. contamination of a river due to non-compliant discharges from an industrial plant)

46. Type of environmental damage *

- ◯ Incident
- ◯ Violation
- ◯ Other

47. Reference date of the event *

(i.e. the date for an incident or the reference period for violations)

48. Regulatory scope of the case *

- ◯ ELD case
- ◯ Non-ELD case

49. For Non-ELD case, specify the relevant legislation *

50. Type of procedure under the case is inquired *

- ◯ Legal
- ◯ No legal
- ◯ Both

51. Activity that determined the environmental damage *

- [ ] Waste management
- [ ] Disposal of contaminants in water
- [ ] Disposal of contaminant on soil
- [ ] Omitted reparation of contaminated areas
- [ ] Impacts on vegetal species
- [ ] Impacts on animal species
- [ ] Mining
- [ ] Fire
- [ ] Illegal buildings
- [ ] Other

52. Site interested by the environmental damage event *

- ◯ Plant for the waste management
- ◯ Industrial plant
- ◯ Purification plant
- ◯ Transportations (e.g. shipping incidents)
- ◯ Natural area
- ◯ Quarry
- ◯ Livestock
- ◯ Manufacturing sector
- ◯ Other

53. Natural resources damaged *

(ref. Article 2 – Directive 2004/56/EC)

- [ ] Protected species
- [ ] Natural habitat
- [ ] Surface water
- [ ] Groundwater
- [ ] Land
- [ ] Air
- [ ] Other

54. Have geospatial intelligence techniques been used to support general assessment of the event? *

(e.g. description and characterization of the territorial context)

- ◯ Yes
- ◯ No

55. Provide a synthetic description of the usage of the geospatial techniques to support the general assessment of the event *

(e.g. description and characterization of the territorial context)

56. Have geospatial intelligence techniques been used to support the assessment of environmental damage remediation? *

(e.g. definition of the measures or monitor their follow-up)

- ◯ Yes
- ◯ No

57. Synthetic description of the usage of the geospatial techniques to support the assessment of environmental damage remediation *

Provide the following information about entity of the damaged natural resources to be repaired:

- For the protected species: number of damaged individuals
- For natural habitat: extension of damaged area
- For superficial water: extension/length of the damaged water body
- For underground water: extension of the damaged water body
- For land: extension of damaged area

58. Have geospatial intelligence techniques been used to support the individuation of the proofs of environmental damage? *

- ◯ Yes
- ◯ No

59. Provide a synthetic description of the usage of the geospatial techniques to support the individuation of the proofs of environmental damage *

60. Data used to analyse the status of the natural resources *

- ☐ Data from competent authority: to be specified (e.g. ecological/chemical status under Directive 2000/60/EC)
- ☐ Field data collected in specific surveys realized after the damage event
- ☐ Remote sensing data
- ☐ Other

61. Methods used in the evaluation of environmental damage *

- [ ] Comparison between the ante/post status of the natural resource (e.g. the chemical status under Directive 2000/60/EE)
- [ ] Statistical analysis
- [ ] Geostatistical analysis
- [ ] Comparison between data from surveys and the threshold values defined by the law
- [ ] Comparison between the status of the natural resource in an area with negative impacts due to the damaging occurrence and a non-impacted area
- [ ] Usage of specific software for the evaluation of environmental damage
- [ ] None
- [ ] Other

Section C

62. Are there databases of legal environmental judgments in your country? *

- ◯ Yes
- ◯ No
- ◯ I don't know

63. Specify the name of existing databases, access options, and point of contact for database access *

64. Do you know any cases where the geospatial intelligence is used to individuate the proofs of other environmental violations (e.g. under Environmental Crime Directive 2008/99/EC or other national laws) *

- ◯ Yes
- ◯ No

65. Which is the source of the information about the environmenal violation? *

(e.g. database, repository, reports. Source reference or web link is highly appreciated)

66. Synthetic description of the case *

(e.g. contamination of a river due to non-compliant discharges from an industrial plant)

Section D

67. Do you know the geospatial intelligence? *

- ◯ Yes
- ◯ Yes, buy I need to have more information
- ◯ No

68. From your point of view, geospatial intelligence techniques can: *

(Please select one of the 5 options)

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	No opinion
Increase environmental surveillance by providing early-waning detection of eco-criminal acts	◯	◯	◯	◯	◯	◯
Provide evidences for the imminent threat of damage cases	◯	◯	◯	◯	◯	◯
Provide evidences for the confirmation of environmental damage	◯	◯	◯	◯	◯	◯
Provide evidences for the confirmation of environmental crime	◯	◯	◯	◯	◯	◯
Provide quantitative information that can support the assessment of environmental damage	◯	◯	◯	◯	◯	◯
Provide quantitative information that can support the assessment of environmental crime	◯	◯	◯	◯	◯	◯
Increasing the evaluation capacity of judges and prosecutors	◯	◯	◯	◯	◯	◯
Support environmental damage ascertainment	◯	◯	◯	◯	◯	◯
Supporting the monitoring of remediation measures for environmental damage	◯	◯	◯	◯	◯	◯
Satellite remote sensing can provide ex-post information to analyze the status of natural resources before damage	◯	◯	◯	◯	◯	◯
Details on the algorithms used to generate qualitative and	◯	◯	◯	◯	◯	◯

quantitative information must be provided						
69. rmation, remarks, concerns, requests, suggestions						
The methodological approaches used to produce the evidence must be intelligible and reproducible						
Uncertainty measures should be provided along with the estimates	◯	◯	◯	◯	◯	◯
There is a need to build capacity of environmental agencies to use geospatial intelligence	◯	◯	◯	◯	◯	◯
Making use of expertise from private companies certified for performing Geospatial Intelligence analysis	◯	◯	◯	◯	◯	◯
There is the need to better identify terms and requirements from prosecutors and judges for use geospatial intelligence to produce evidences of eco-criminal acts	◯	◯	◯	◯	◯	◯
Improving efficiency in the ascertainment phase by preliminary analysis using geospatial intelligence	◯	◯	◯	◯	◯	◯