

29 September - 01 October 2026 ESA-ESRIN | Frascati | Italy

Environmental Crimes joint workshop with ESA-JRC-UNODC

Use of satellite imagery for monitoring livestock effluent spreading and farming activities



Nadia Fibbiani, Dario Bellingeri, Gian Paolo Oneda, Maria Paola Caffi
ARPA Lombardia

Introduction



Population: almost 10 million citizens

Area: 23,800 km²

Population density: 420 inhabitants/km²

Provinces: 11 + 1 Metropolitan City

Municipalities: more than 1500

Local Prosecutor's Offices: 13

General Prosecutor's Offices: 2

Factories: > 100,000

Farms: > 50,000

IED installations: 1800 (30% of Italy)

Seveso Plants: 270 (25% of Italy)

Waste management facilities: 2100 (20% of Italy)

ARPA is a **Public Institution** with administrative, organizational, technical and economic autonomy

Lombardia is the first Italian region for population and for the number of local institutions, the first for population density and the fourth for total surface



ARPA Lombardia, the **Regional Environmental Protection Agency** of Lombardy, was established in 1999 by Regional Law n. 16 and became fully operating in 2000

www.arpalombardia.it

Introduction



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ARPA LOMBARDIA
Agenzia Regionale per la Protezione dell'Ambiente
Dip. regionale per l'Innovazione, la ricerca e la sostenibilità
U.O. Centro Regionale Earth Observation

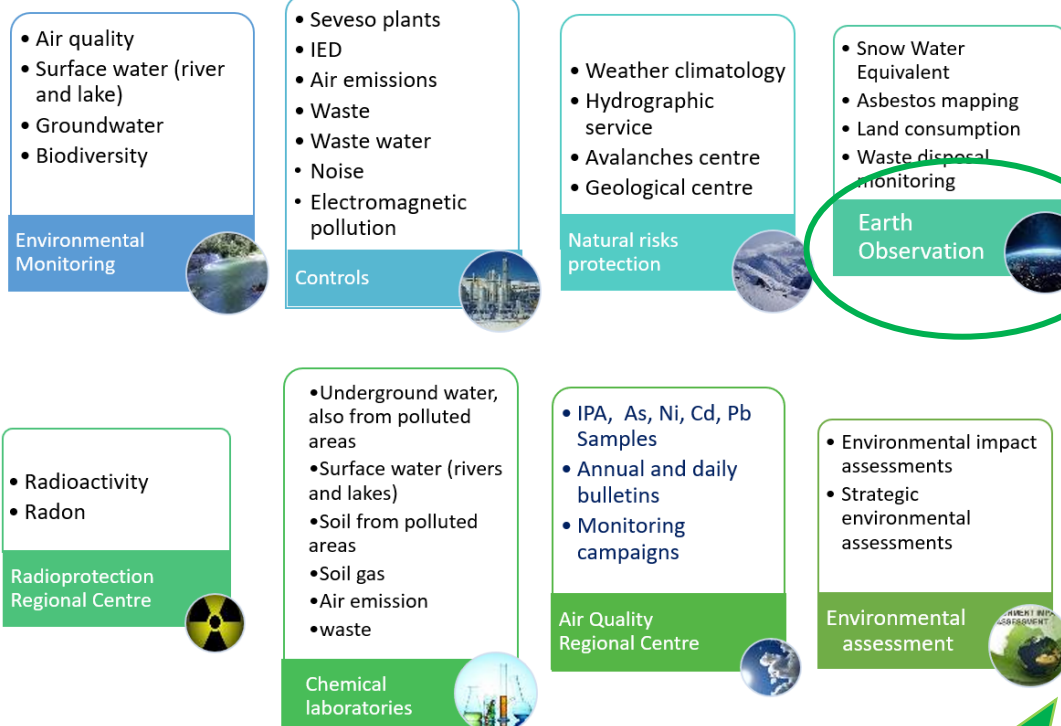
Operational applications of Earth Observation data at different scales, supporting environmental controls and inspections:

Experiences from the Regional Environmental Protection Agency (ARPA) of Lombardy, Italy

Dario Bellingeri, Nadia Fibbiani, Elena Gatto, Martina Griffi, Andrea Lamonaca, Alessandro Menin, Vito Sacchetti
U.O. CREO (Centro Regionale di Earth Observation), ARPA Lombardia



ARPA Lombardia – main activities:



U.O. CREO (Regional Center for Earth Observation)

- Development of **operational services** based on **Earth Observation** and GIS tools, to support the Agency's institutional environmental **monitoring** and **control** activities
- **Research and innovation**, testing of **new technologies** and development of methodologies based on remote sensing data acquired from different aerial platforms (**satellite, aircraft, drone**) or from the ground.



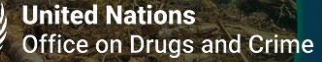
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**Livestock effluents monitoring and control:
the context in Lombardy region**

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In Lombardy, land application of livestock effluents for agronomic purposes is regulated by regional policies, which mandate compliance with specific operational and management requirements, alongside a prohibition during designated winter periods.

European, national and regional main regulatory references:

- Dir. 91/676/CEE – “Nitrate Directive”.
- Dir. 2010/75/UE IED – “Integrated Emissions Directive”
- D.Lgs. 152/2006 (Codice dell’Ambiente) – Recepimento in Italia Dir 91/676/CEE
- Decreto interministeriale 25 febbraio 2016 “Programma d’Azione Nitrati nazionale”.
- D.G.R. XII/4284 del 30/04/2025 – Aggiornamento del Programma d’Azione Nitrati 2024-2027 per le zone vulnerabili.
- D.G.R. XII/4285 del 30/04/2025 – Aggiornamento delle Linee guida regionali per le zone non vulnerabili ai Nitrati.
- D.G.R XII/1944 del 26 /02/2024 – Proroga del Programma d’Azione Nitrati 2020-2023 per le zone vulnerabili.

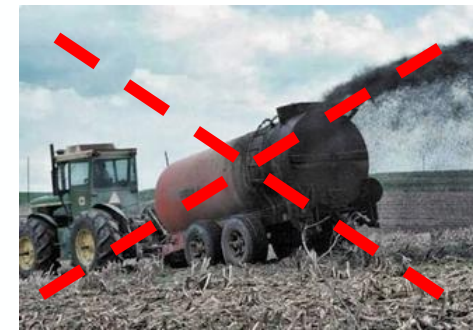


Livestock effluents monitoring and control: the context in Lombardy region

Under the Nitrates Directive and the resulting national and regional rules and regulations, the spreading of livestock effluent and urban sewage sludge is subject to specific temporal, spatial, and operational/methodological constraints.

Applications are totally banned from 1 December to 31 January.

During November and February, stops to applications are possible, depending on meteorological conditions (defined in a specific bulletin from ERSAF).



ZONE PEDOCCLIMATICHE		18-feb	19-feb	20-feb	21-feb	GIORNI DI DIVIETO RESIDUI
1	Alpi	SI	NO	NO	SI	0 giorni
2	Prealpi occidentali	SI	NO	NO	SI	0 giorni
3	Prealpi orientali	SI	NO	NO	SI	0 giorni
4	Pianura occidentale	SI	NO	SI	SI	0 giorni
5	Pianura centrale	SI	NO	SI	SI	0 giorni
6	Pianura orientale	SI	NO	SI	SI	0 giorni

In any case, spreading is not permitted on rainy days or the days immediately following, where soil trafficability is compromised and in the presence of standing water or on frozen or snow-covered ground. These practices may only be carried out on declared and designated plots and must adhere to a precise schedule, following appropriate operational methods.

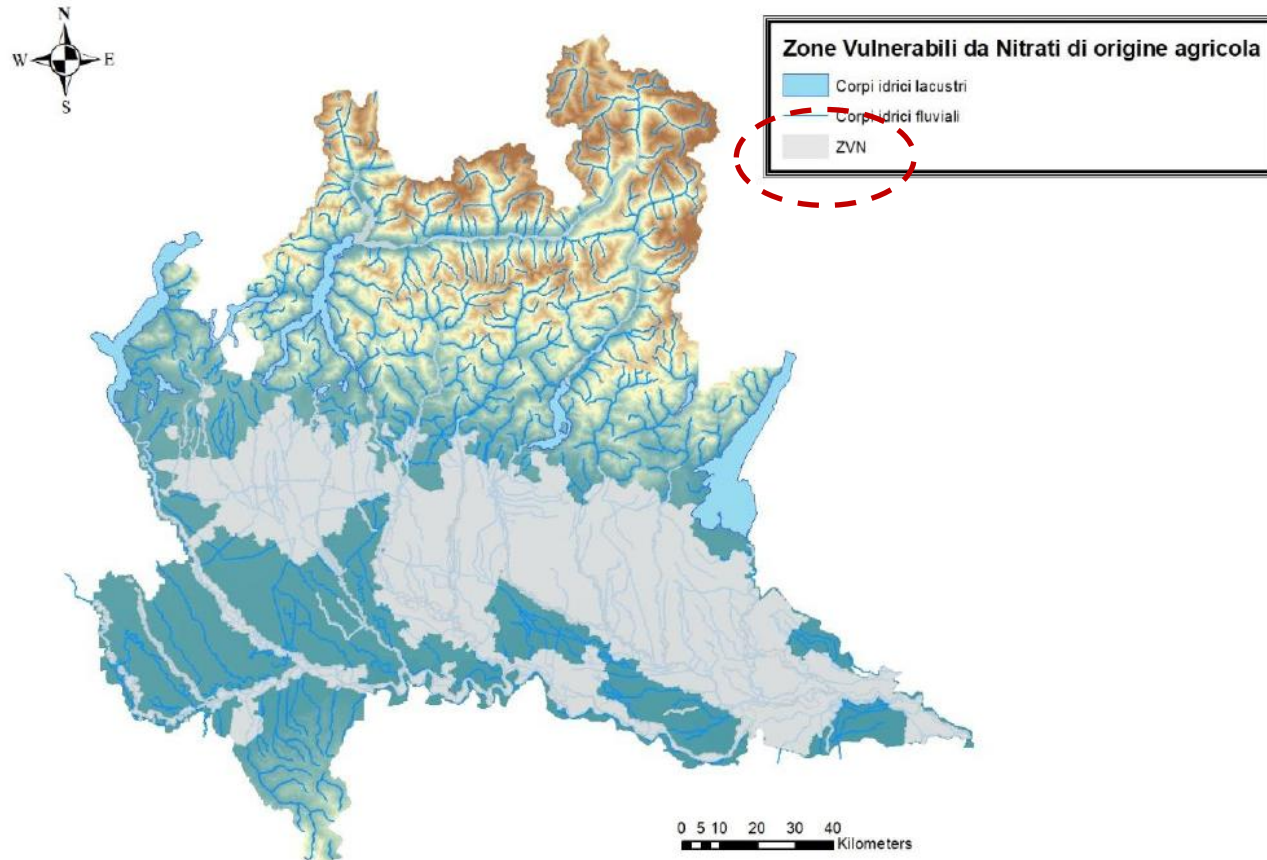
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The context in Lombardy:

Pressures:

- 10 millions inhabitants
- > 1.5 millions cattles
- > 3.7 millions pigs
- Thousands of breeding farms
- 750 facilities operating under **IED code 6.6**

Vulnerability:

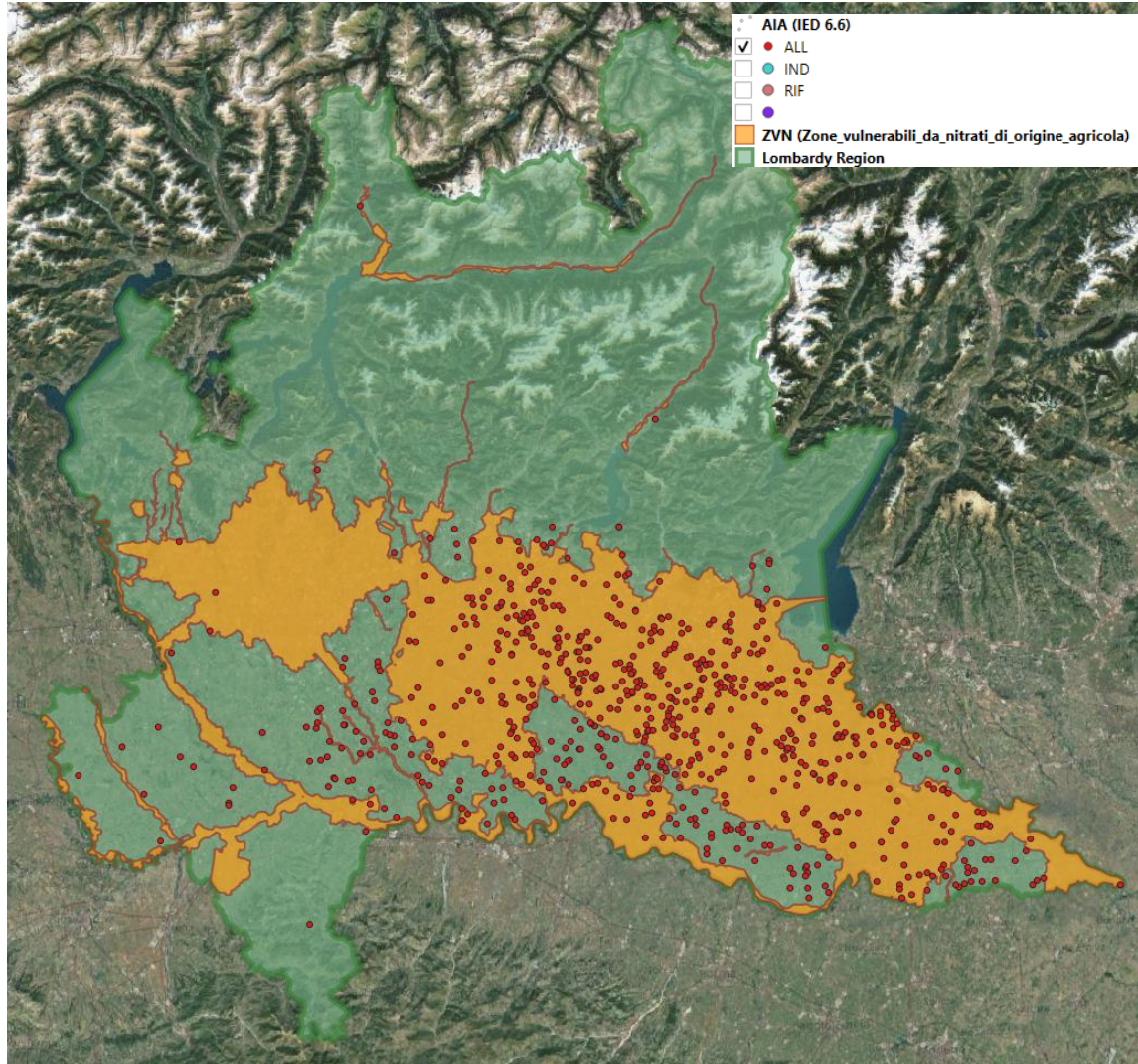
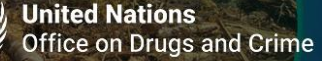
In Lombardy, over 50% of the plain is classified as **Nitrate Vulnerable Zone (ZVN)**; more than 630 municipalities are wholly or partially within ZVN.

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The context in Lombardy:

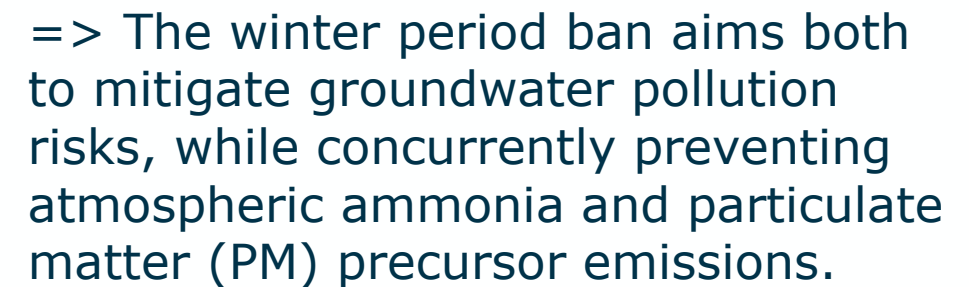
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INEMAR ARPA LOMBARDIA
Inventario delle emissioni nel 2023
www.inemar.eu



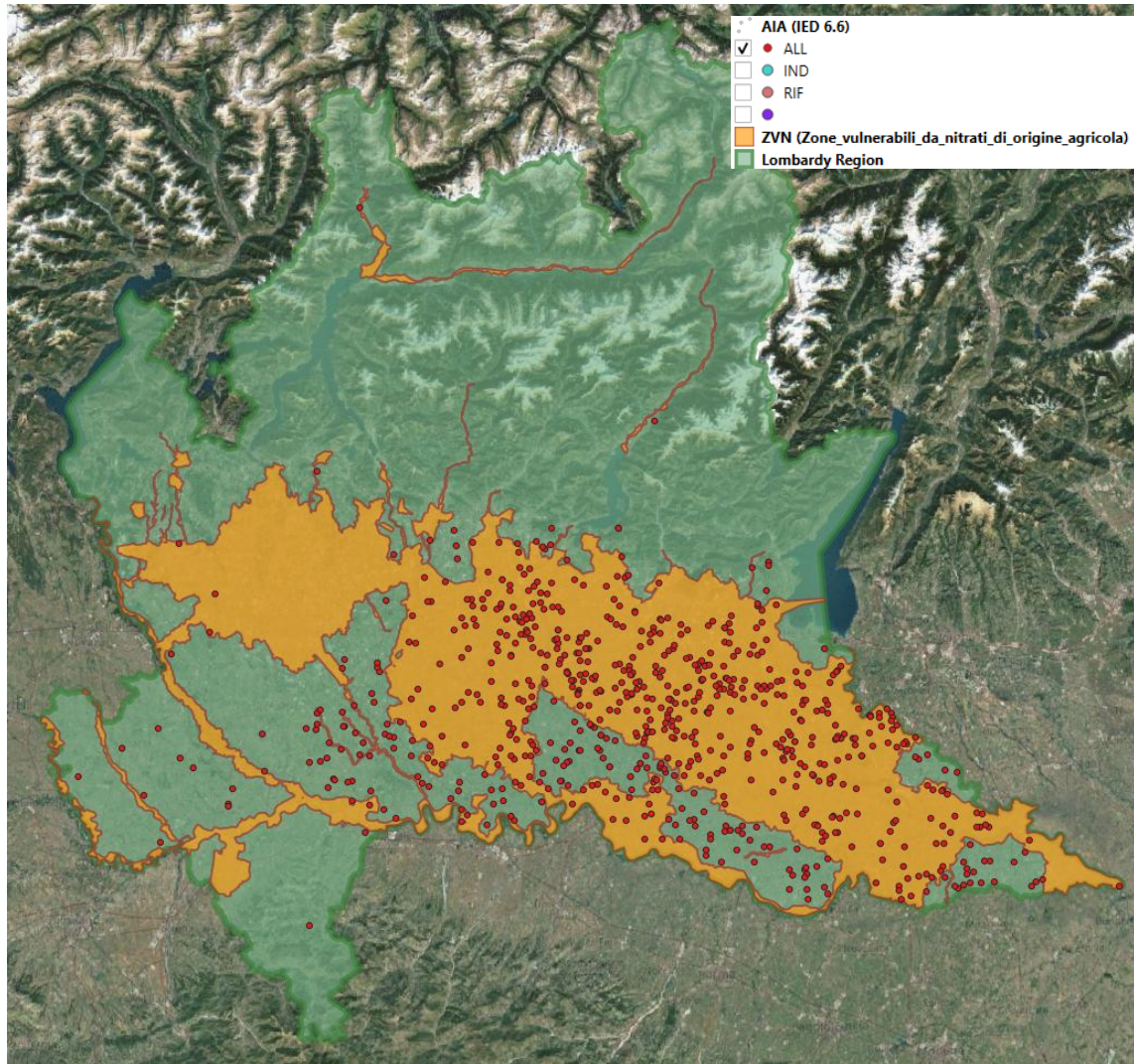
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➤ 750 facilities operating under **IED code 6.6**

These installations are subject to periodic inspections by ARPA, sometimes supported by the operational use of Earth Observation tools from various platforms.

Although ARPA lacks direct statutory competence over smaller, non-IED farms, the Agency frequently conducts targeted investigations into alleged irregular spreading activities triggered by citizen complaints or after requests from Judicial Police bodies.

Livestock effluents monitoring and control: opportunities from EO data at different scale



To overcome the logistical constraints of traditional on-site inspections, ARPA has implemented a remote monitoring system utilizing high-temporal-frequency satellite imagery.

Earth Observation (EO) data contributions are applicable in many operational contexts and at different scales:

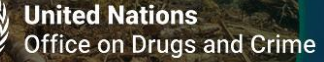
- Development of a large-scale observation tool: monitoring, planning support, assessment of local derogations, etc.
- Verification of compliance with good agricultural practices (e.g., adherence to spreading ban periods, observance of spatial constraints, etc.)
- Support for planning and conducting inspections: this approach tracks potential environmental criticalities and provides robust hints of illicit spreading operations

**Livestock effluents monitoring and control:
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ARPA Lombardia experiences, evolutions..

Initial assessments of use in support of EO data: 2016 feasibility study

Examples: back-analysis of specific cases

Comparisons between VHR satellite or aerial data as ground truth and medium resolution satellite data



Google Earth 12/03/2014.

Multispectral satellite data
Landsat 8 **13/03/2014.**



Livestock effluents monitoring and control: opportunities from EO data at different scale



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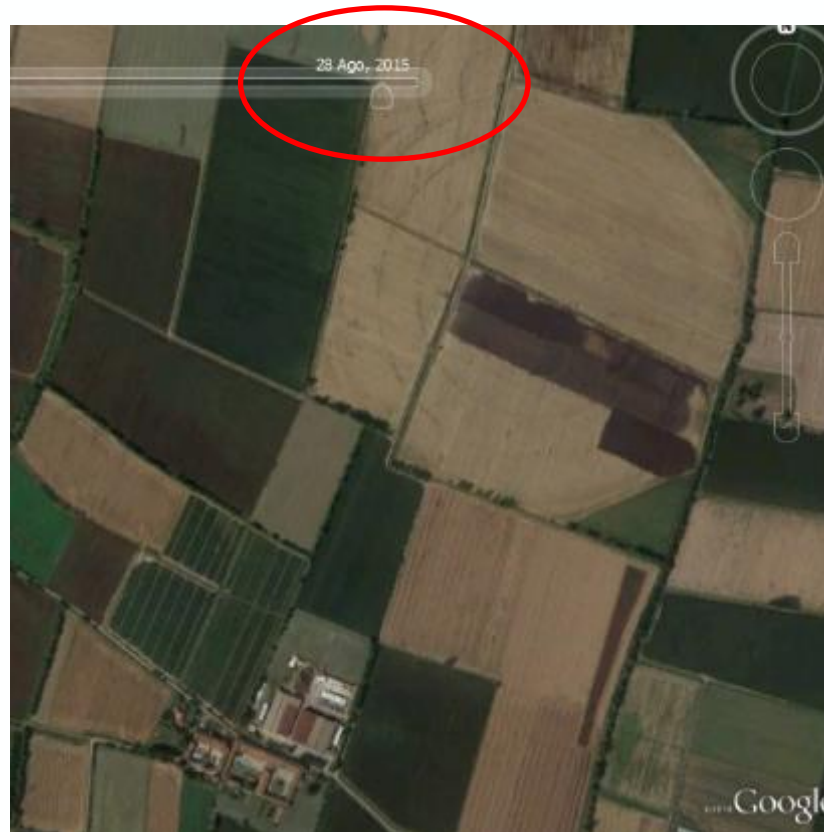
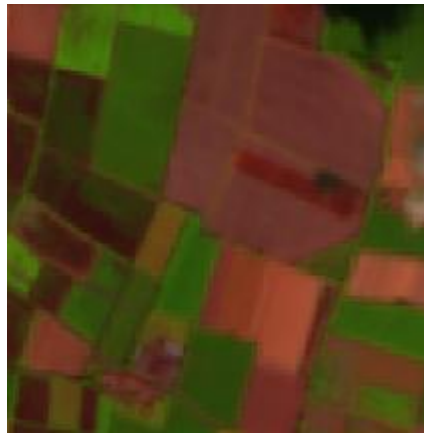
ARPA Lombardia experiences,
evolutions..

Initial assessments of use in support of
EO data: 2016 feasibility study

A first “game changer”:
the Copernicus program!!



Sentinel-2
before: 26/08/2015



Sentinel-2
after: 12/09/2015



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ARPA Lombardia experiences,
evolutions..

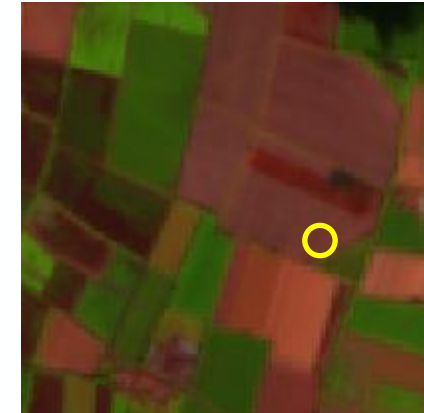


Evaluation of spectral
response over time, in
different situations during
effluent disposal

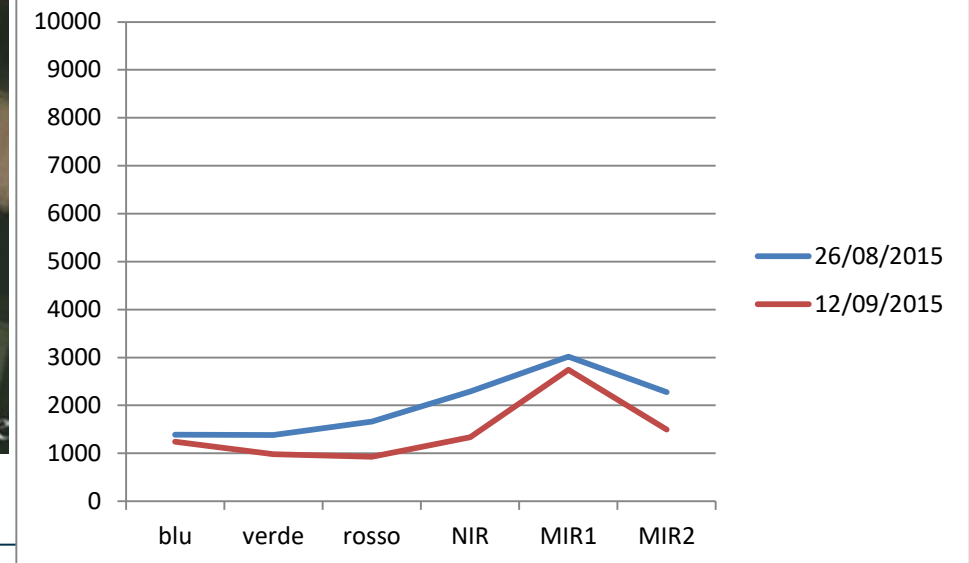


Effluent application after 28/8

Sentinel-2
before: 26/08/2015



Sentinel-2
after: 12/09/2015

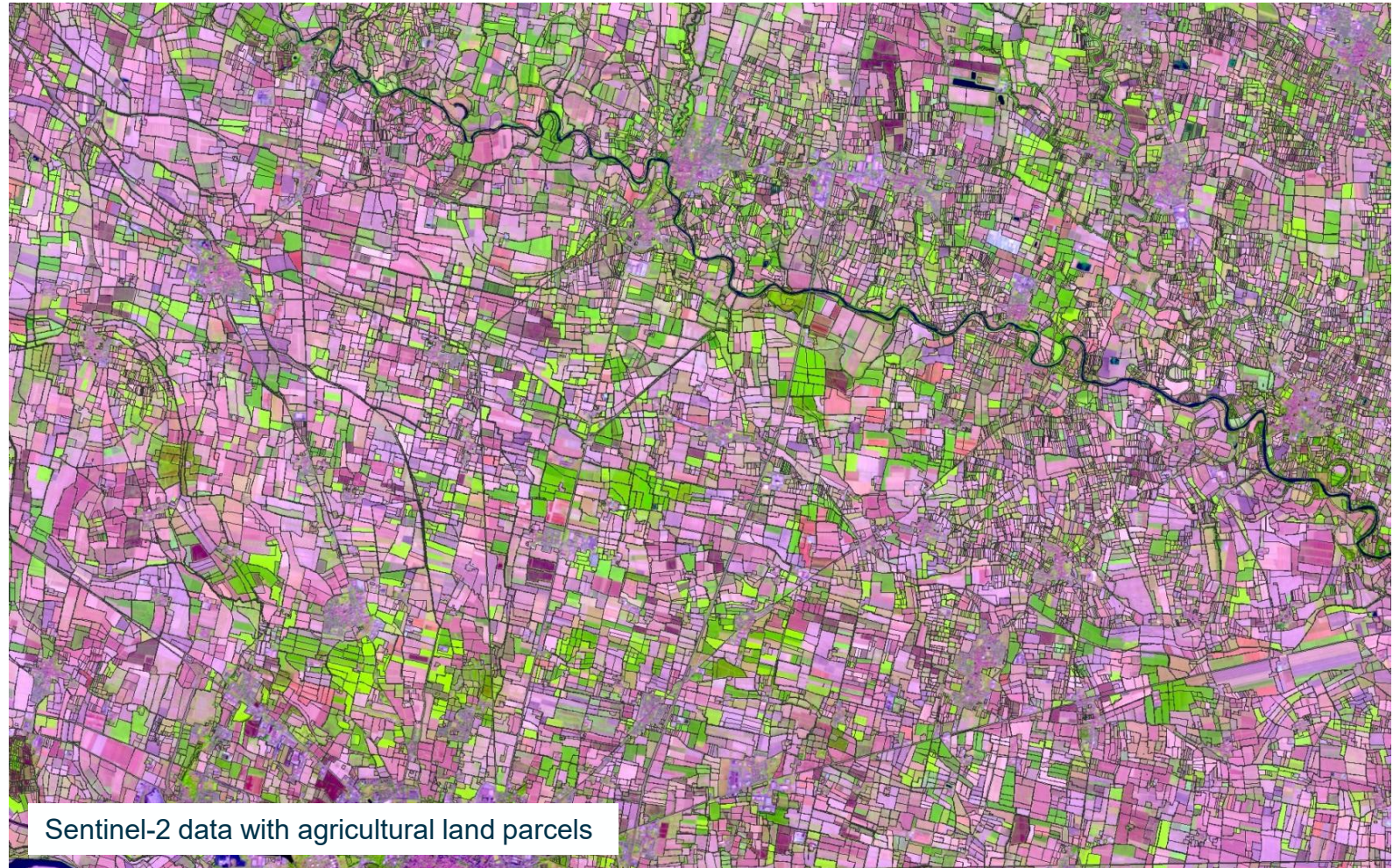
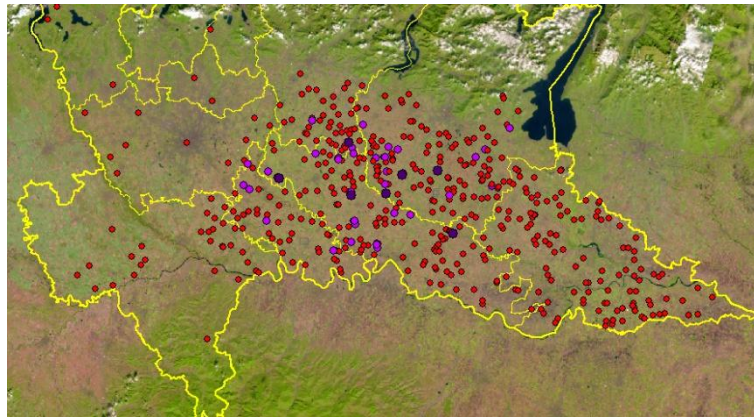


Livestock effluents monitoring and control: opportunities from EO data at different scale



ARPA Lombardia experiences,
evolutions..

.. towards applications at wide scale...



Sentinel-2 data with agricultural land parcels

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.. towards applications at wide scale...
... or supporting local analysis...

A photograph showing a wide, flat expanse of dark, muddy ground, possibly a construction site or a flooded field. In the foreground, there is a dense patch of green grass and weeds. A portion of a car's side mirror is visible in the bottom left corner. The background features a line of trees and a tall, thin structure, possibly a tower or antenna, under a cloudy sky.

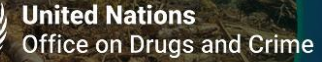


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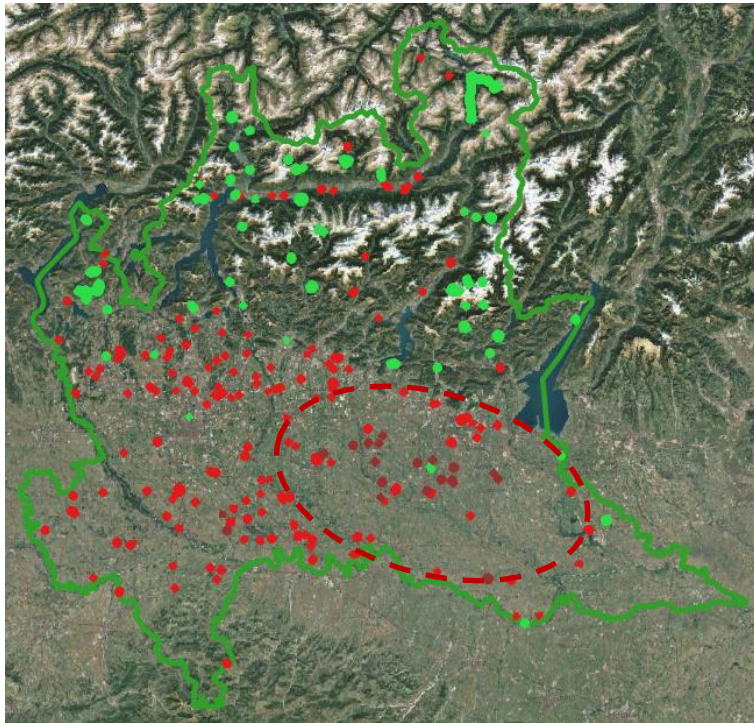


Operational usage of high temporal frequency and higher spatial resolution commercial satellite data

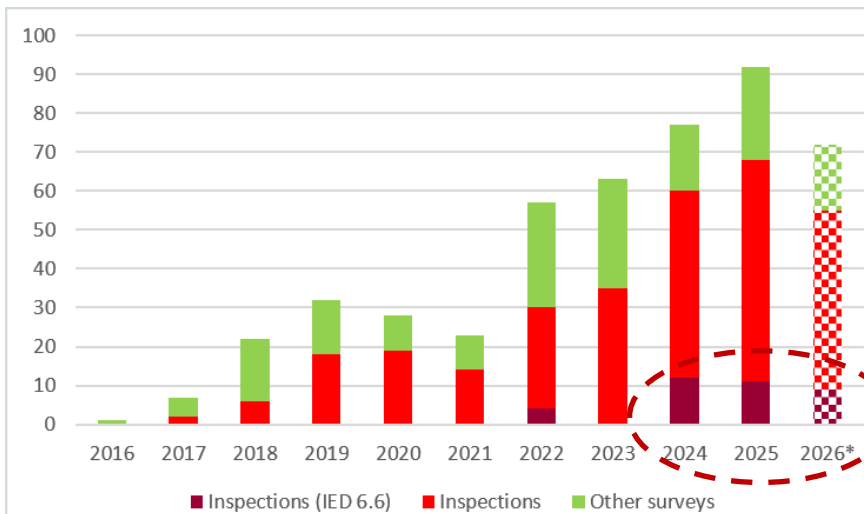


Livestock effluents monitoring and control: opportunities from EO data at different scale

In addition to satellite data, Unmanned Aerial Vehicles (UAVs/drones) are also deployed to monitor livestock facilities, particularly when sites are inaccessible due to sanitary restrictions.



Locations and temporal evolution of ARPA's UAS surveys. In red, surveys related to inspections and controls



From 2024: Limitation to direct inspections due to swine fever disease

 Regione Lombardia

Regione Lombardia - Giunta
DIREZIONE GENERALE WELFARE
VETERINARIA
Piazza Città di Lombardia n.1
20124 Milano
Tel 02 695.1

Prot. arpa_mi.2024.0120586

Oggetto: PSA ingressi in allevamento - disposizioni finalizzate alla riduzione del rischio

Stante l'attuale situazione epidemiologica nei confronti della PSA, risulta prioritario diminuire qualsiasi fattore di rischio di introduzione e diffusione della malattia negli e tra gli allevamenti suini.

Questo al fine di tutelare il patrimonio zootecnico lombardo sia da un punto di vista sanitario che economico.

Fatto salvo l'obbligo del puntuale e rigoroso rispetto di tutte le misure di biosicurezza previste dalla norma, si ritiene opportuno, in considerazione di quanto sopra, evitare o quanto meno ridurre al minimo gli ingressi negli allevamenti suini, non strettamente collegati alle attività di allevamento e gestione dell'emergenza.

Quindi, si inviano codesti DV e gli altri Enti in indirizzo a sospendere, stante il carattere emergenziale della attuale situazione epidemiologica, le attività che implicano un accesso in allevamento sia di mezzi che persone e che non siano strettamente collegate alle attività di controllo e sorveglianza della malattia o comunque ritenute inderogabili al fine di garantire la salute e benessere degli animali.

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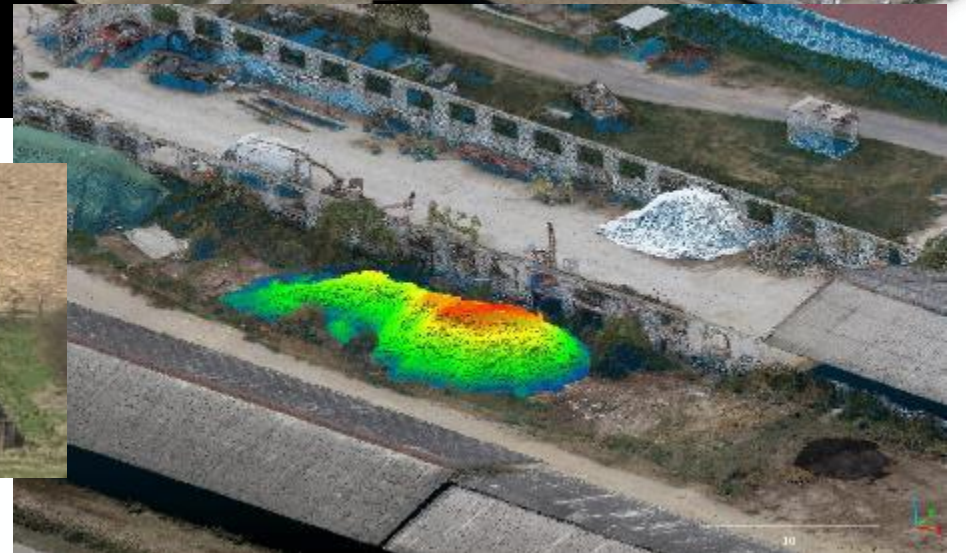
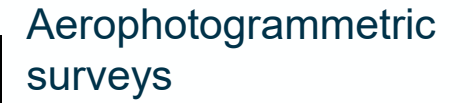
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UAVs support to livestock facilities inspections, examples:



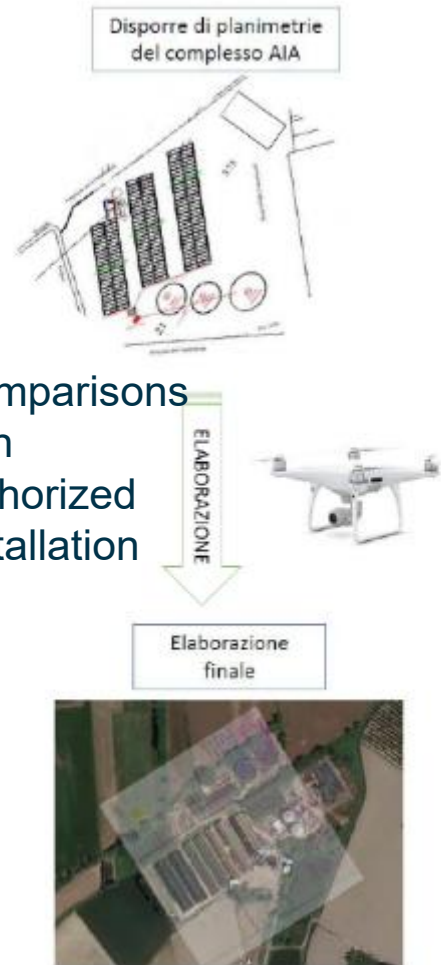
Aerophotogrammetric



Verification of facilities (e.g. effluent collection tanks)

Livestock effluents monitoring and control: opportunities from EO data at different scale

UAVs support to livestock facilities inspections, examples:



Installations
measurements



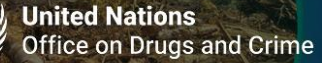
Verifications of
specific
prescriptions
(e.g. effluent
tanks covering)

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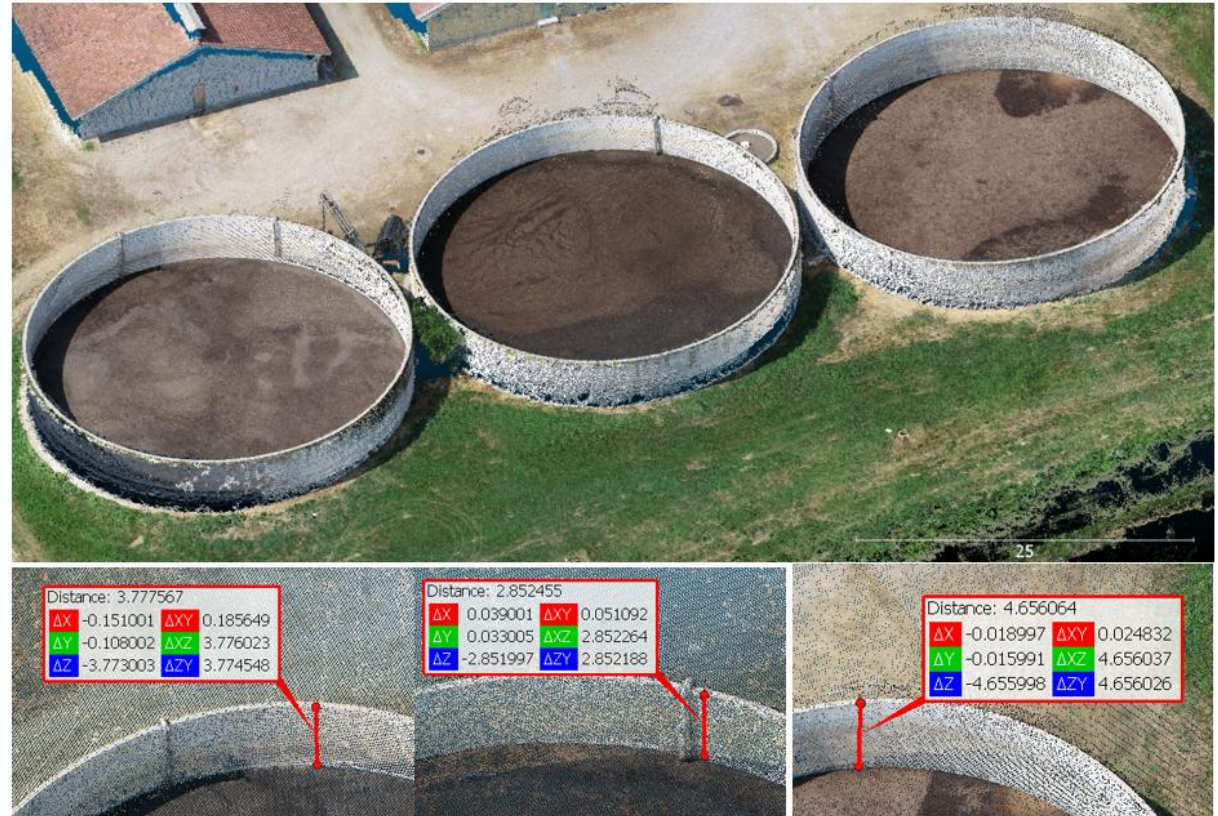
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UAVs support to livestock facilities inspections, examples:



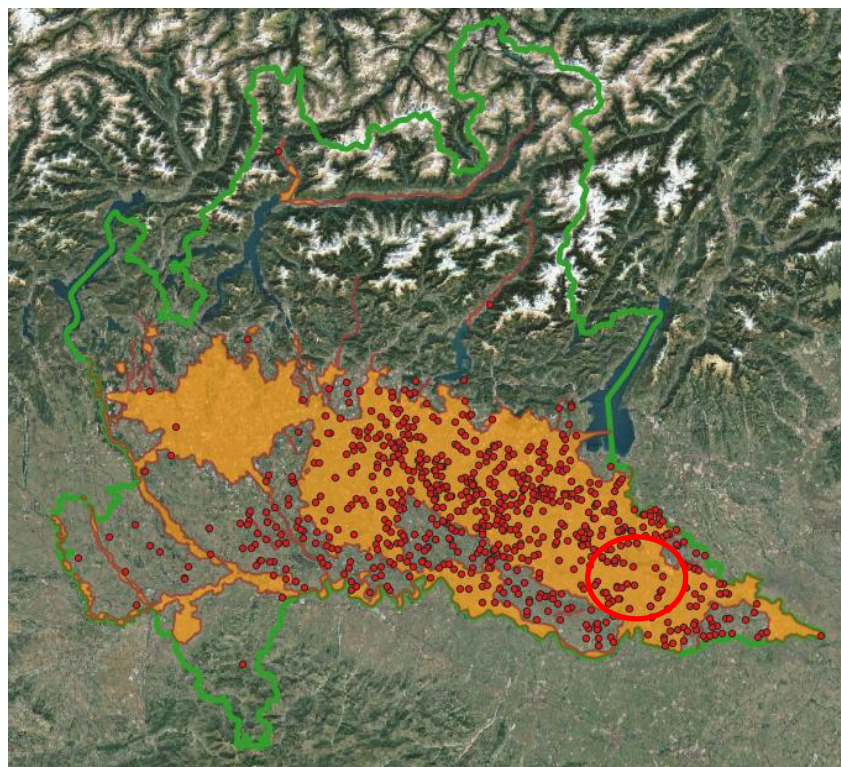
Verifications of specific prescriptions
(e.g. effluent tanks covering,
volumetric estimations,...)



Livestock effluents monitoring and control: A real case



The specific case begun after complaint received by ARPA Cremona-Mantova department, related to supposed illicit management of livestock effluents by a IED 6.6 installation, located in Nitrate Vulnerable Area.

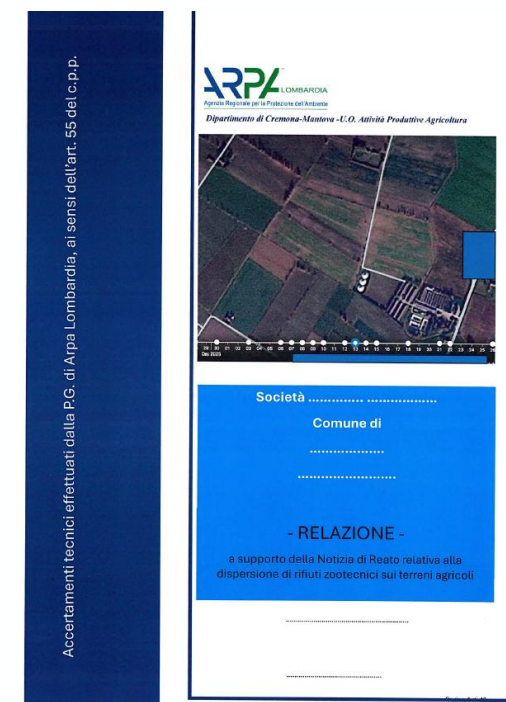


Multitemporal EO satellite data from different sources were used for preliminary evaluation, inspections planning, and verified with field inspections.



This work led to the notification of a suspected crime ("CNR – Comunicazione Notizia di Reato")

Technical report on the examinations conducted by the ARPA Lombardia judicial police.

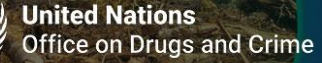


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- Tasking of high resolution satellite data (SkySAT, 50 cm res.), useful for detailed and updated overview of the area of interest



Examples of licit applications of livestock effluents

Livestock effluents monitoring and control: A real case



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Preliminary activities:

- Research and definition of the specific agricultural land parcels of potential interest



Livestock effluents monitoring and control: A real case



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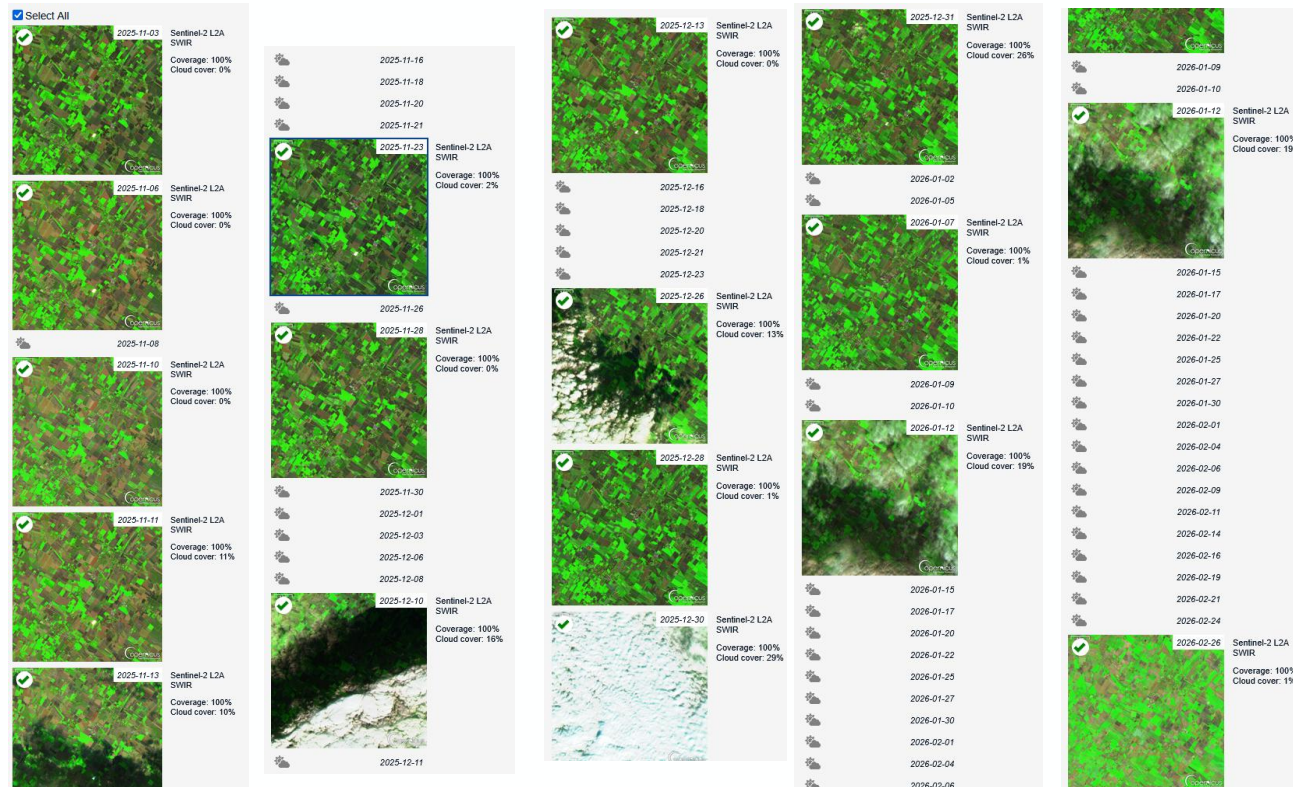


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Multitemporal evaluation from EO satellite data

- Sentinel-2 option



Timelapse of potentially useful S-2 acquisitions in the period nov25 – feb26



Livestock effluents monitoring and control: A real case



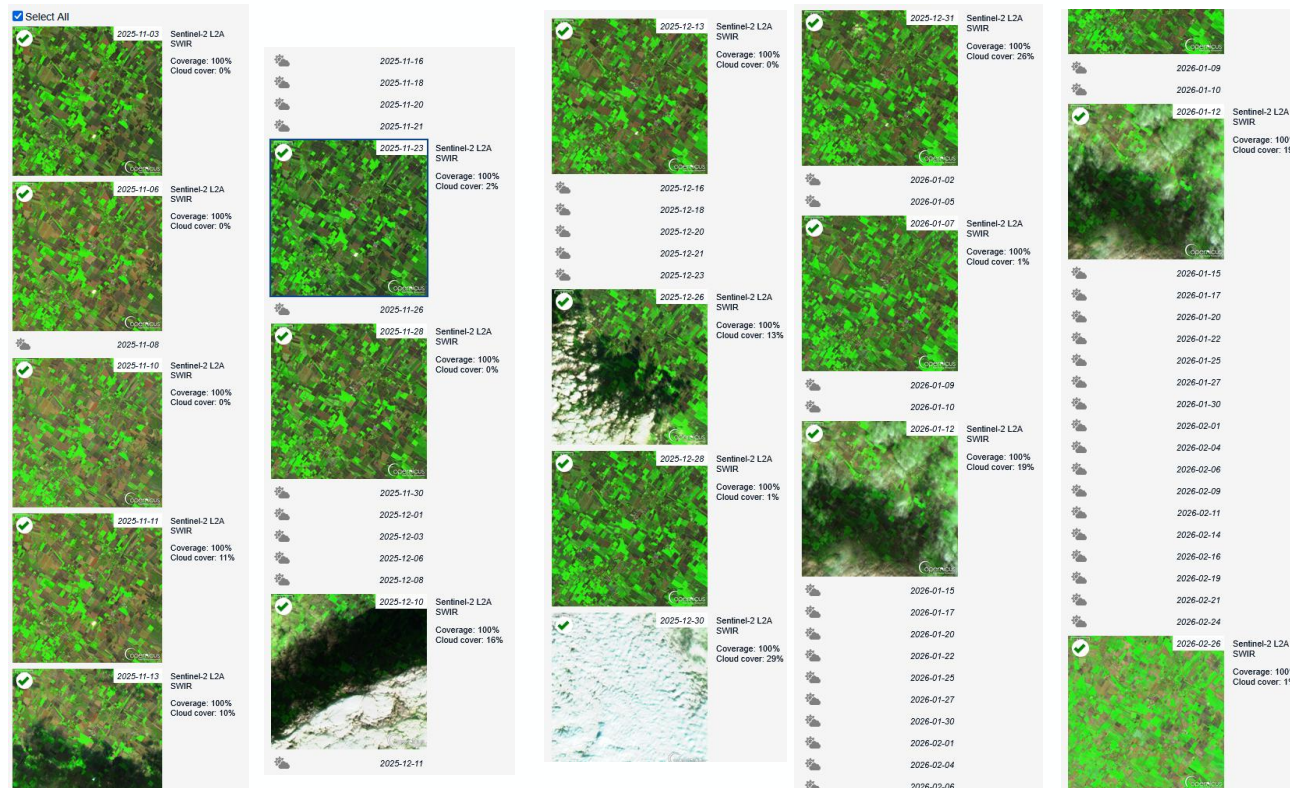
Multitemporal evaluation from EO satellite data

- Sentinel-2 option



Timelapse of potentially useful S-2 acquisitions in the period nov25 – feb26

Detail in the specific AOI:



Livestock effluents monitoring and control: A real case

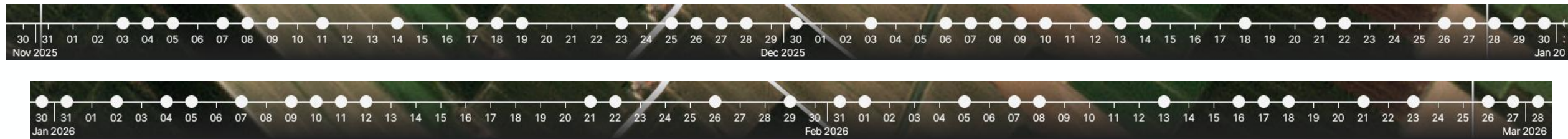


Multitemporal evaluation from EO satellite data

- Planetscope option



Temporal availability of potentially useful Planet-Dove
daily acquisitions in the period nov25 – feb26:



Livestock effluents monitoring and control: A real case



Multitemporal evaluation from EO satellite data

- Planetscope option



Timelapse of the most useful
Planet-Dove acquisitions in the
period nov25 – jan26

Detail in the specific AOI:



[LINK](#)

Livestock effluents monitoring and control: A real case



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Summary of the technical report, supporting the notification of a suspected crime:

Sommario

1. Premessa.....
- 1.1 Normativa di riferimento relativa allo spandimento dei reflui.....
2. Accertamenti condotti sui luoghi
- 2.1 Sopralluogo del 18 ottobre 2025.....
- 2.2 Sopralluogo del 08 novembre 2025.....



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Summary of the technical report, supporting the notification of a suspected crime:

Sommario

4. Conclusioni

1. Prem

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2.6 S

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3.7 F

3.8 F

3.9 V

4. Con

Come già illustrato nelle premesse, la condotta illecita della società ha due possibili norme incriminatrici:

- 1) l'uso non conforme dei reflui zootecnici come fertilizzanti, sanzionata dalle norme regionali e/o dall'art.137, co. 14 del TUA, in relazione all'offensività delle condotte;
- 2) l'abbandono di rifiuti, descritto dall'art. 192 del TUA e sanzionato (nel caso di specie, quali rifiuti non pericolosi) dagli artt. 255 e 255 bis del TUA.

Alla luce dell'elemento soggettivo del dolo, posto che il gestore era pienamente consapevole del divieto di distribuzione dei reflui nel periodo compreso tra il 1° dicembre e il 31 gennaio, e considerato che in tale arco temporale difetta oggettivamente qualsivoglia finalità agronomica, deve rilevarsi come la condotta si sia protratta nel tempo ed abbia interessato una superficie pari a circa 11 ettari, ricadente in area classificata vulnerabile ai nitrati di origine agricola ai sensi della D.G.R. Regione Lombardia n. 3297/2006.

L'effettuazione di spandimenti su terreni privi di coltivazioni e in periodo di divieto comporta il venir meno della funzione e dell'utilità agronomica degli effluenti zootecnici, unica condizione giuridicamente idonea a sottrarli alla disciplina dei rifiuti.

Ne consegue che il comportamento del responsabile aziendale integra gli estremi della volontà di disfarsi dei reflui, i quali, per effetto della condotta descritta, devono essere qualificati giuridicamente come rifiuti.

Key elements:

- EO data provided solid hints of the potential illicit
 - Reiteration of the activity
 - Reiteration over the same land parcels, during total ban period
- The illicit was timely verified and contested directly in field
- During field surveys, other criticalities were verified
- Formal notification of a suspected crime ("*CNR-Comunicazione Notizia di Reato*", for illicit abandonment of waste)



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Many thanks for your attention



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Contact: d.bellingeri@arpalombardia.it