Aspects of interoperability in LULUCF

Rafal Zielinski (EEA) / EO4MRV'25 / 07.10.2025

Outline

- Foundational EU frameworks on interoparability
- Regulatory framework in LULUCF and in relation to other EU policies/initiatives
- Practical approach for reuse data and fit for purpose analyses
- Example of Cross-Domain Alignment in LULUCF (CAP example)

Foundational EU Frameworks on Interoperability

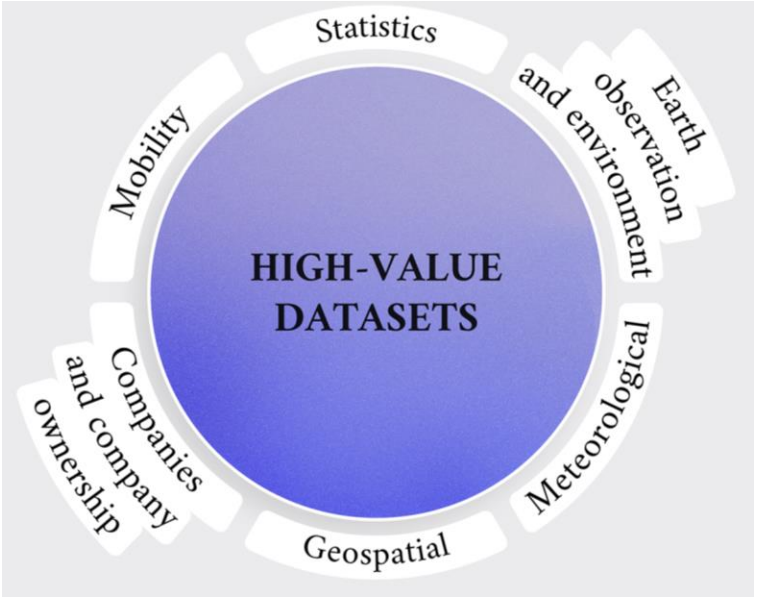
Why it matters?

- **Avoids duplication** of data collection.
- Ensures cross-border and cross-sector **services can work together**.
- **Critical for EU digital** public services (i.e. land & environmental monitoring).

- **INSPIRE Directive (2007/2/EC)**
  - Establishes the **Infrastructure for Spatial Information in the European Community**.
  - Provides harmonised standards for metadata, data models, network services, and interoperability of spatial datasets across Member States.

- **European Interoperability Framework (EIF)** – (2024/903/EU)
  - EU-wide strategic framework promoting **technical, semantic, organisational, and legal interoperability** in public sector digital services.

- **Open Data Directive (2019/1024/EU)**
  - Requires publication of public sector information in **machine-readable, interoperable formats**.
  - Basis for the **High-Value Datasets Implementing Regulation (EU) 2023/138**, which mandates free, API-based access to **geospatial, earth observation, and environment data.**



High-value datasets (overview)

Gerry Lawson, Co-benefits of the CRCF: **Session 4**

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European Interoperability Framework (EIF)

- Legal interoperability
  - **Aligning rules, regulations, and policies** so that data/services can be shared lawfully across borders.
  - Example: GDPR enabling consistent rules for personal data protection.
- Organizational interoperability
  - Aligning business processes and **responsibilities across administrations**.
  - Example: two national agencies harmonizing workflows to share land registry data.
- Semantic interoperability
  - Ensuring **data has the same meaning** when exchanged.
  - Example: "forest land" should mean the same in all Member States' reporting systems.
- Technical interoperability
  - **Common IT standards, protocols**, APIs enabling data exchange.
  - Example: INSPIRE metadata standards, or Copernicus open APIs for geospatial data.

Source: capgemini.com

"Interoperability is the **ability** of organisations and systems **to exchange**, **understand and use data** and services seamlessly **across** borders, **sectors and technologies**."

[Regulation - EU - 2024/903 - EN - EUR-Lex]

Regulatory framework in LULUCF

Gov Reg 2018/1999 Annex V Part 3:

- For monitoring and reporting in the LULUCF sector, Member States shall use **geographically explicit land-use conversion data** in accordance with the 2006 IPCC Guidelines for national GHG inventories

…geographically explicit land-use

- Member States are encouraged **to explore synergies and opportunities to consolidate** reporting **with other relevant policy areas** and strive towards greenhouse gas inventories which allow for **interoperability with relevant electronic databases and geographic information systems**…

…explore synergies with other relevant policy areas

….interoperability (in) land-use information

- The greenhouse gas inventory **shall enable the exchange and integration of data between the electronic databases and the geographic information systems**, in order to facilitate their comparability and public accessibility.

….interoperability (out) GHG inventory

Other requirements mentioned already by Lucia/Peter! **@Session 1**

Improving accuracy and robustness of estimates of GHG inventories

IPCC 2006 Tiers and Approaches for implementing **LULUCF Reg. 2018/841**

Tier 3 **High res. data (e.g. model)**	Not applicable	Modelled data combined with LUC matrix (not necessarily spatially dis-aggregated)	Geo-information at high-resolution, detailed time series, country-specific disaggregated data based on inventories and/or models
Tier 2 **Country specific values**	National area statistics, combined with country-specific values – typical 1st improvement	Annual LUC stats, combined with country-specific values	Geo-information, time series, country specific values – good coverage, detailed analysis
Tier 1 **IPCC default values**	National area statistics, combined with IPCC default values – basic entry level	Annual (or annualised) LUC stats presented as national matrix – applied using default IPCC values	Geo-information, time series, default values – weak, but better than App 1 and 2
	Approach 1 **National statistics**	**Approach 2** **Land Use Change matrix**	**Approach 3** **Geo-tracked**

IACS…

Improved Coverage and Representation

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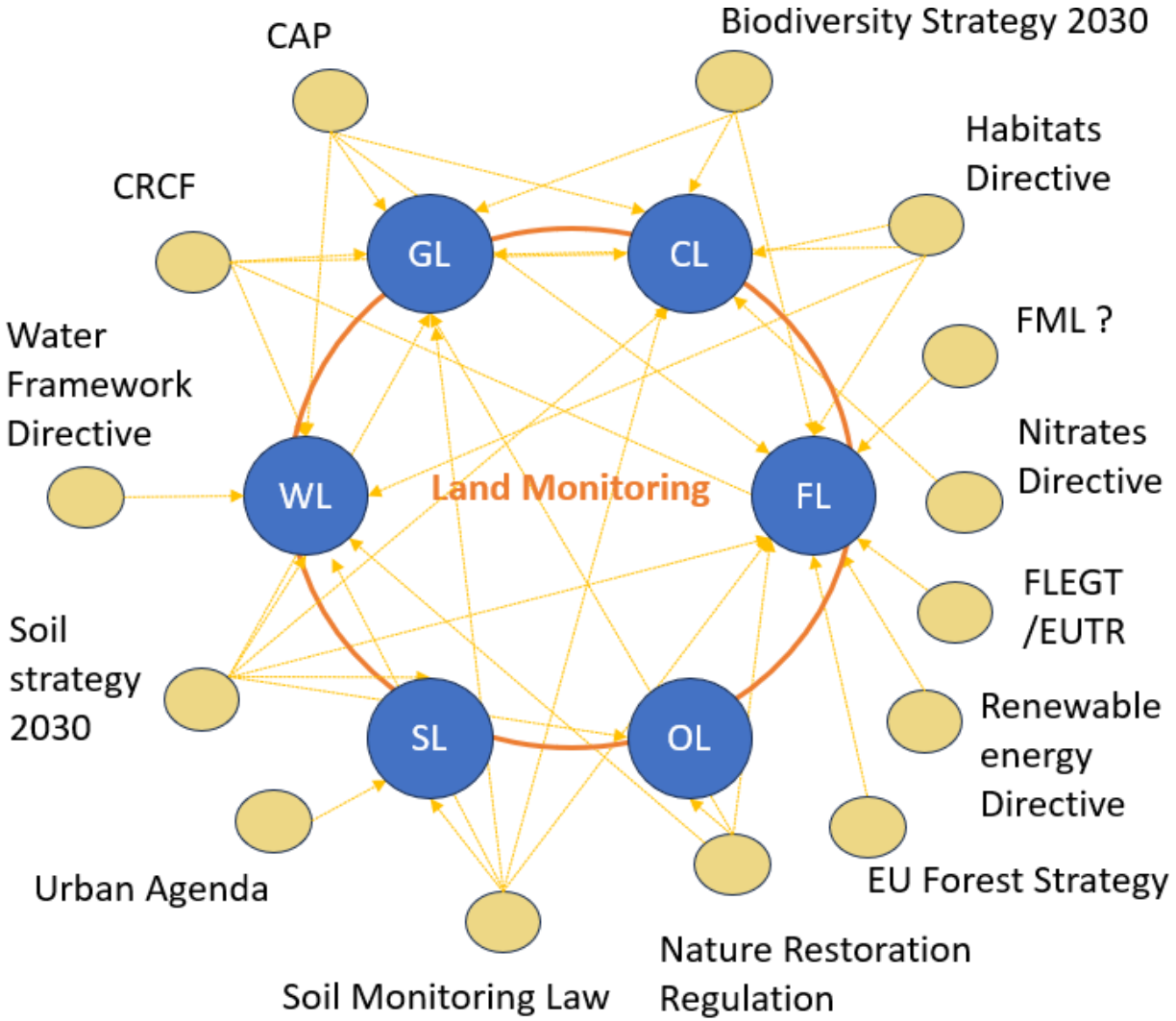
LULUCF categories and relevant polices*

- Each policy **focuses on a selected aspects**
- Is **very specific** and designed to fulfil its own **objectives and purpose**.
- Holds **specific definitions,** often different across MS implementation!

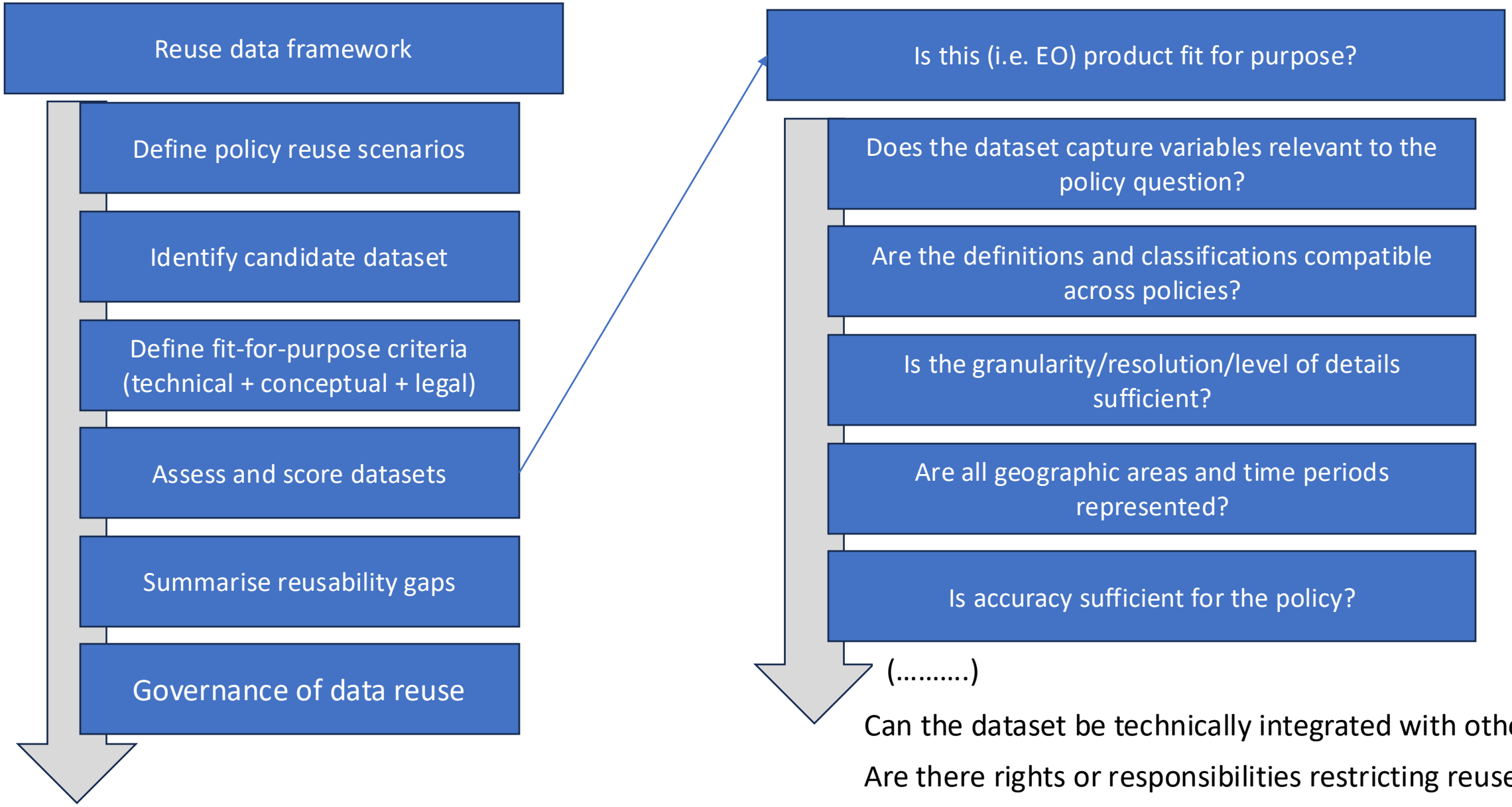
- Has different **legislative status** (in preparation, implemented)
- Follows a certain monitoring, reporting circle (every 1,2,..,5 years)
- May cover **only selected** area of interest or **land object** (forest, agricultural parcel)

- Not all may provide crucial data at first glance (**level of details, spatial explicit component, avalible only for limited time**)
  = important to perform **fit for purpose** analyses



*selected/simplified view

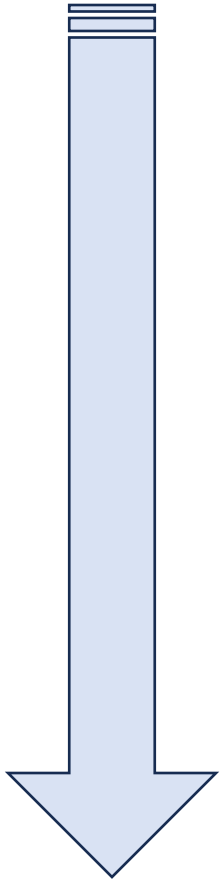
Practical framework for reuse data and fit for purpose analyses



Potential role of IACS data use*

*selected

- **Activity Data for Land Use Categories** (y1, y2,….)
  - To provide georeferenced data on agricultural parcels, crops, and management records
- **Tracking Land Use Change** (y2-y1)
  - Such transitions are essential for the annual LULUCF greenhouse gas inventories, are critical for identifying which areas are cropland, grassland, or have undergone conversions (e.g., cropland to forest).
- **Emission Factor Stratification**
  - Different land uses and management practices have different emission factors. CAP data can help to stratify emission factors in LULUCF models:
  - i.e. tillage vs. no-tillage practice, grassland management intensity (grazing pressure, mowing, fertilization), crop types (perennial vs. annual, root biomass differences).
- **Soil Carbon and Biomass Estimates**
  - CAP soil monitoring (e.g., through agri-environmental indicators and farm surveys) feeds into estimates of soil organic carbon changes in croplands and grasslands.
  - Information on crop rotations, cover crops, or perennial crops under CAP helps refine soil carbon models used in LULUCF accounting.



Improve consistency and reduce uncertainty in LULUCF reporting.

Providing spatial explicit data that are administratively robust and annually updated

Cross-Domain Alignment in LULUCF (CAP example)

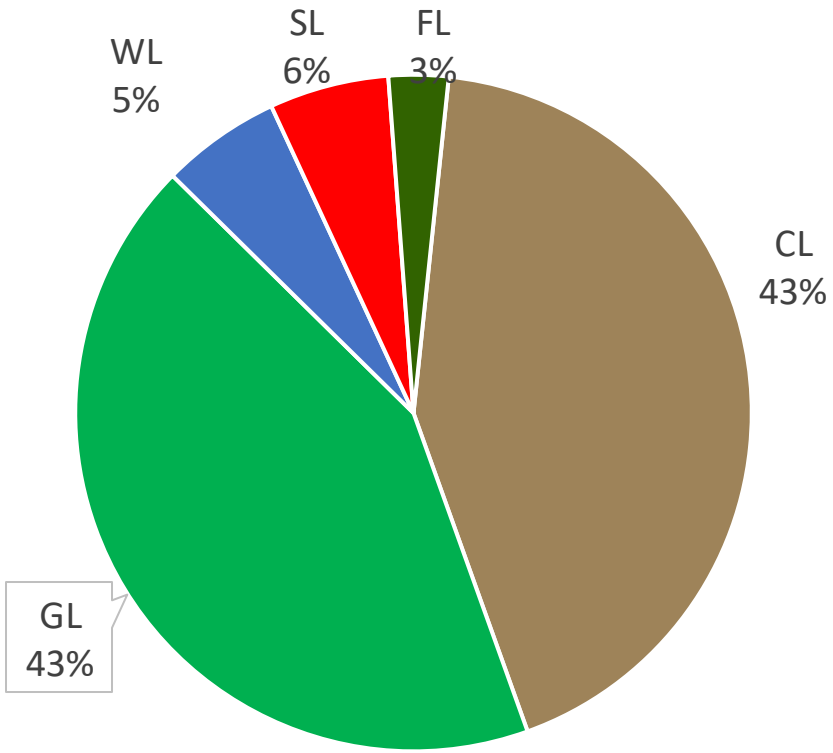
- **CAP classes do not map 1:1 to IPCC categories**
- **Misalignment creates challenges** for greenhouse gas inventory reporting and for monitoring climate mitigation effects of CAP measures.

Mapping Examples

- **Arable land (CAP)** → **usually** falls under Cropland (LULUCF).
- **Permanent grassland (CAP)** → **aligns** with Grassland (LULUCF).
- **Permanent crops (CAP)** → **considered** Cropland (LULUCF), though functionally they may behave like semi-forests in carbon accounting.
- **Agroforestry parcels (CAP)** → **ambiguous**; could be partly Forest Land or Cropland depending on canopy cover and minimum area thresholds.
- **Landscape features / hedgerows (CAP)** → **may be too small for IPCC land categories**, but relevant for carbon stock changes.

- High detalies level of data = disaggregated classes instead of 6 LULUCF categories

As reported data source in the NIR 2024



12/27 MSs mentioned as a data source (mostly: LPIS/GSA)

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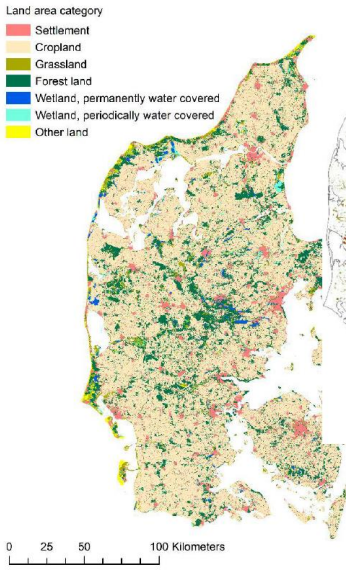
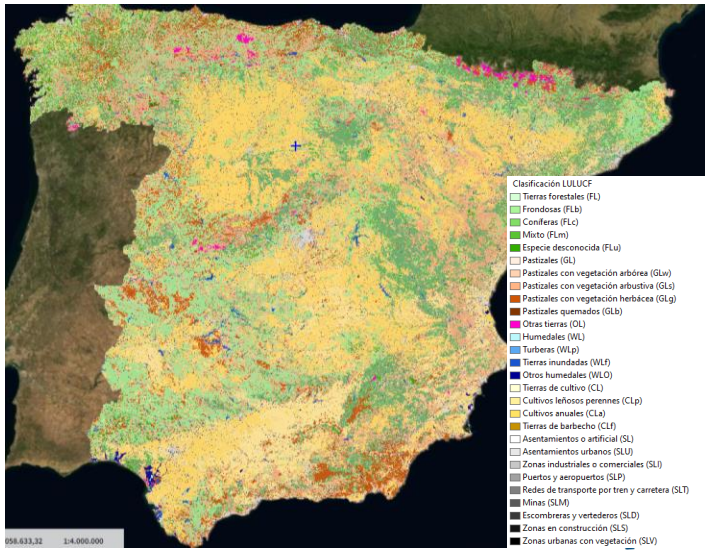
Interoperability Challenges (CAP example)

- **Scale mismatch**: CAP parcels are very fine-grained (farm level), LULUCF categories are broader.
- **Legal mismatch**: CAP definitions are designed for subsidy eligibility, not carbon flux monitoring.
- **Semantic mismatch**: e.g., CAP's "permanent grassland" may include areas that the IPCC would consider "managed wetlands" if waterlogged.
- **Temporal tracking**: cross-domain alignment must bridge short-term administrative updates with long-term climate accounting requirements.

Best practices:

- **Develop correspondence tables** (crosswalks) between LPIS/CAP classes and LULUCF/IPCC categories.
- **Harmonize monitoring systems**: integrate CAP's LPIS data with LULUCF MRV (Monitoring, Reporting, Verification).
- **Establish semantic ontologies linking** administrative and scientific land-use terms.





Interoperability Challenges (CAP example)

- **Spatial correspondence,** as reported in 2024 NIRs, **% of total CL and GL** covered by the LPIS, i.e.:
  - AT: 99%, BG, NL: 100%
  - DK: close agreement of LPIS and Statistics Denmark (±2%)
  - RO: 70%, HR: 60% - (lack of data, sematic issues?)

umweltbundesamt
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Completing the picture: Satellite-based mapping of agricultural land-use to gap-fill the Austria IACS geodatabase

Sebastian Böck, Environment Agency Austria,

2nd Conference on EO4MRV | Copenhagen | 8 October 2025

Due to distant policy objectives and purpose/menagment decision / class definition / data availability / …. **= gaps in data converge**

See Sebastian Böck **@Session 2**

Solution:

- Another dataset (if avalible)
- Collect data, i.e. classify remote sensing imagery/dataset
- Monitor/Report as sub-category?
- (…)

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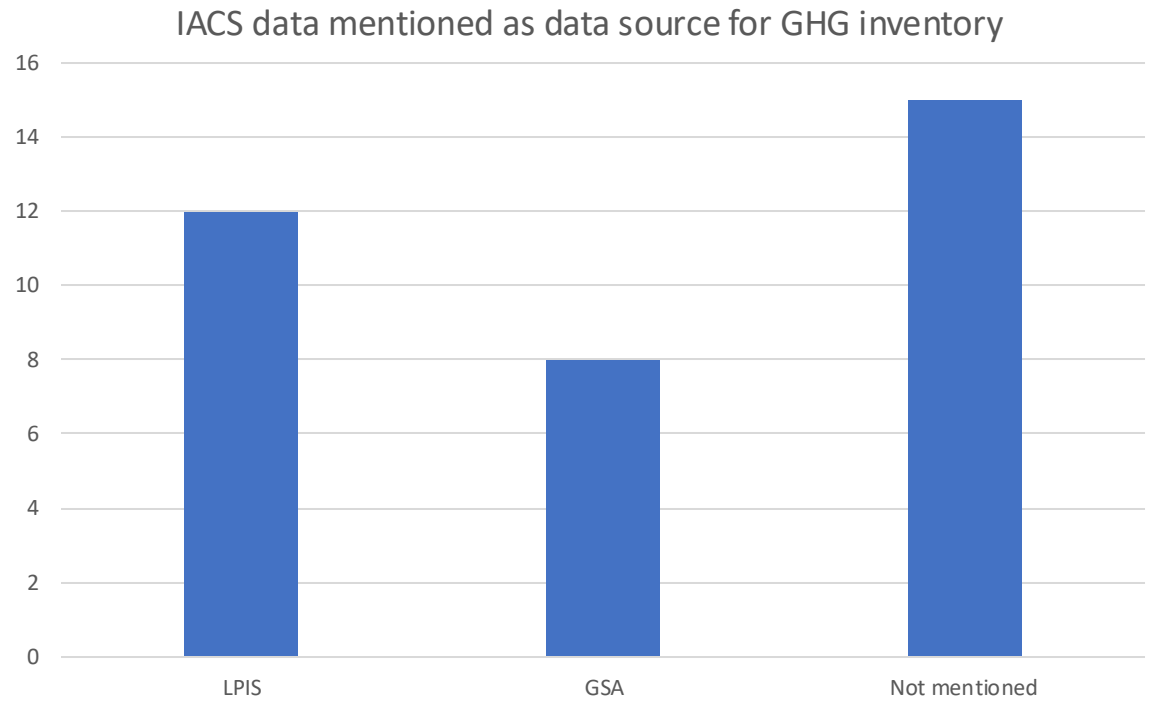
National Inventory Report (NIR) 2024: IACS data used/mentioned

- **12/27 MSs** mentioned as a data source
  - Several MSs indicated as a future use/development of IACS data (e.g. GR, SK)
- Type of information:
  - **LPIS**: agricultural land eligible for CAP subsidies (Land Use/Land Cover)
  - **GSA**: annual information about crop type (Land Cover) for each parcel declared
- Used as:
  - **Spatially explicit**
  - **Tabular** information
  - Other
- **NIR level of details varies** between the MSs
  - limited information or generic information
  - issues with nomenclature

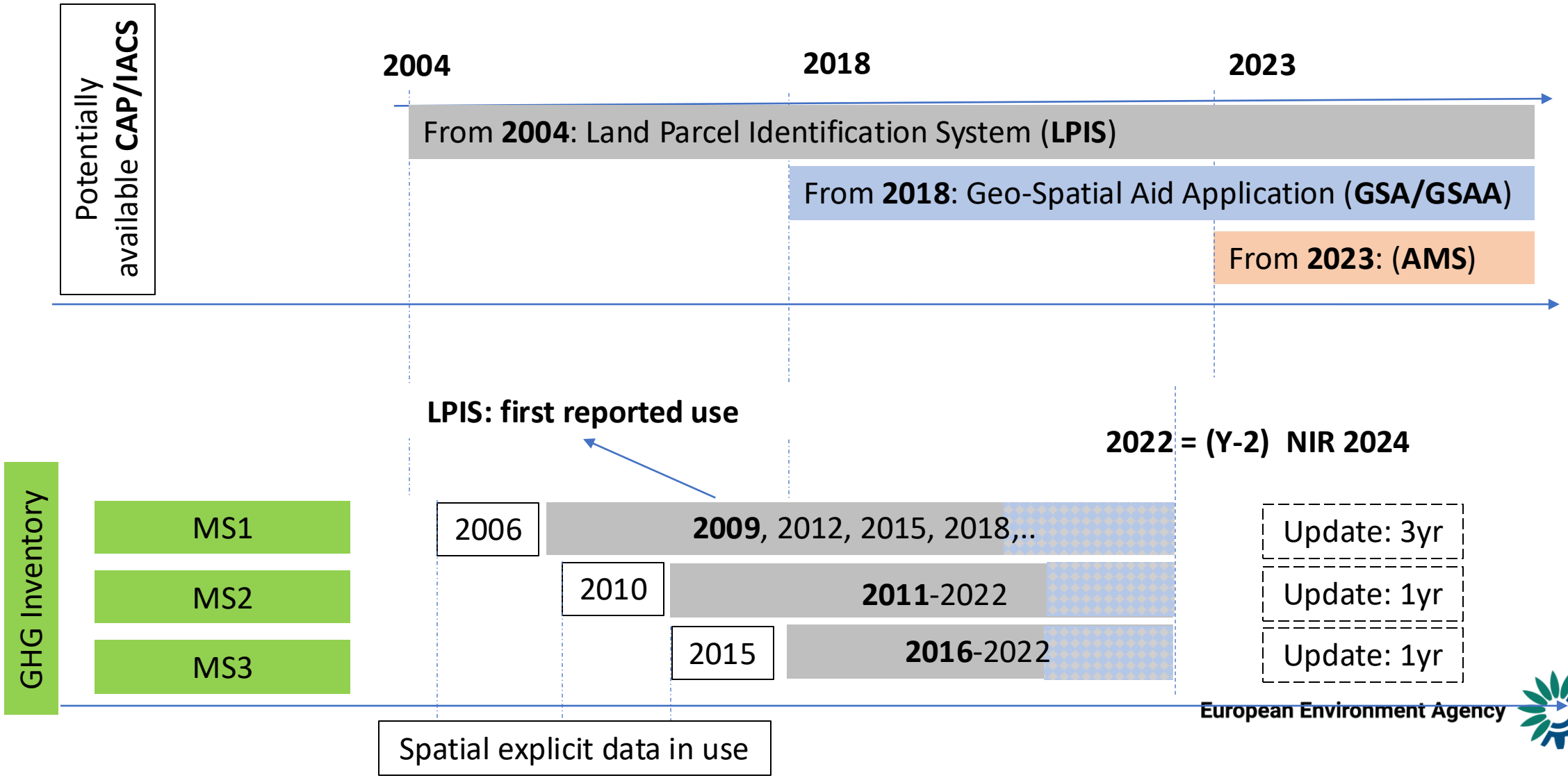


2025 NIR analises → Tobias presentation, session 1

…. to be further investigated

NIR 2024: IACS spatial data contribution to GHG Inventories

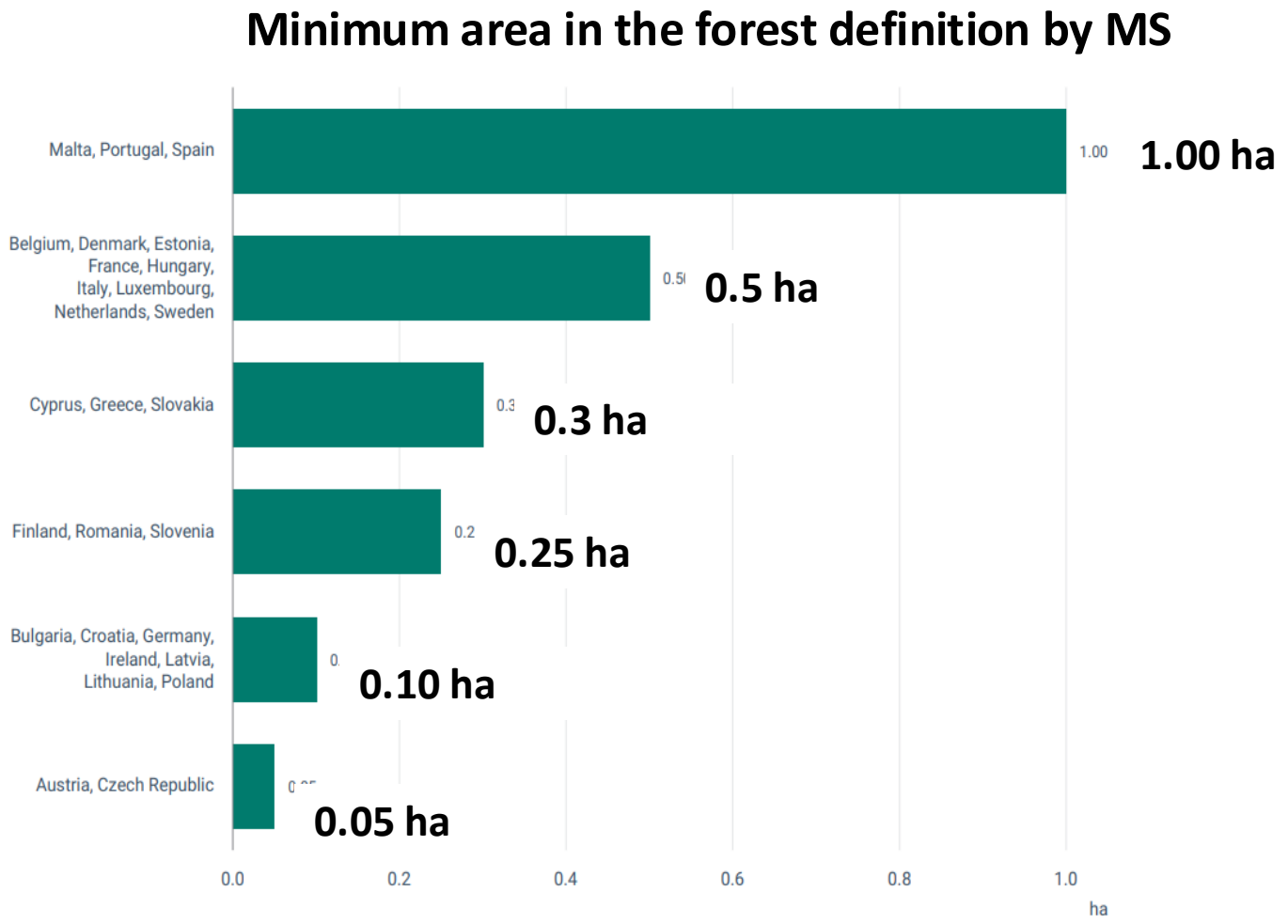
Potentially available CAP data vs **their practical usage** (example of 3 MSs)



Semantic interoperability in LULUCF

Semantic interoperability = shared meaning of **land categories, definitions, and concepts**.

- Shared Definitions: **Common meaning** for terms like forest, cropland, wetland, harvested wood products.
- Cross-Domain Alignment: **Mapping** CAP farm parcels ↔ LULUCF accounting categories.
- Temporal Consistency: **Stable definitions** across decades (e.g., afforestation since 1990).
- Policy Impact: Avoids double counting, ensures comparability, enables automated reporting.



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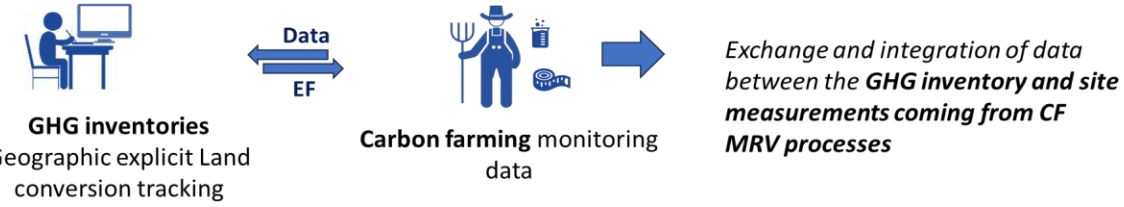
Way forward

- Explore **synergies** between other **polices /datasets**
- Work on data **semantic ensures policy-relevant categories map** correctly across these systems
- **Reuse existing data** (i.e. IACS/LPIS) and future (i.e. CRCF, FML?) monitoring and reporting data
- Support **interoperability** of land use data
- Encourage **data sharing**
- **Enhanced collaboration between EO community, policymakers, inventory agencies, researchers**



Opportunity for improving inventories with measured data

Collect once, use multiple times

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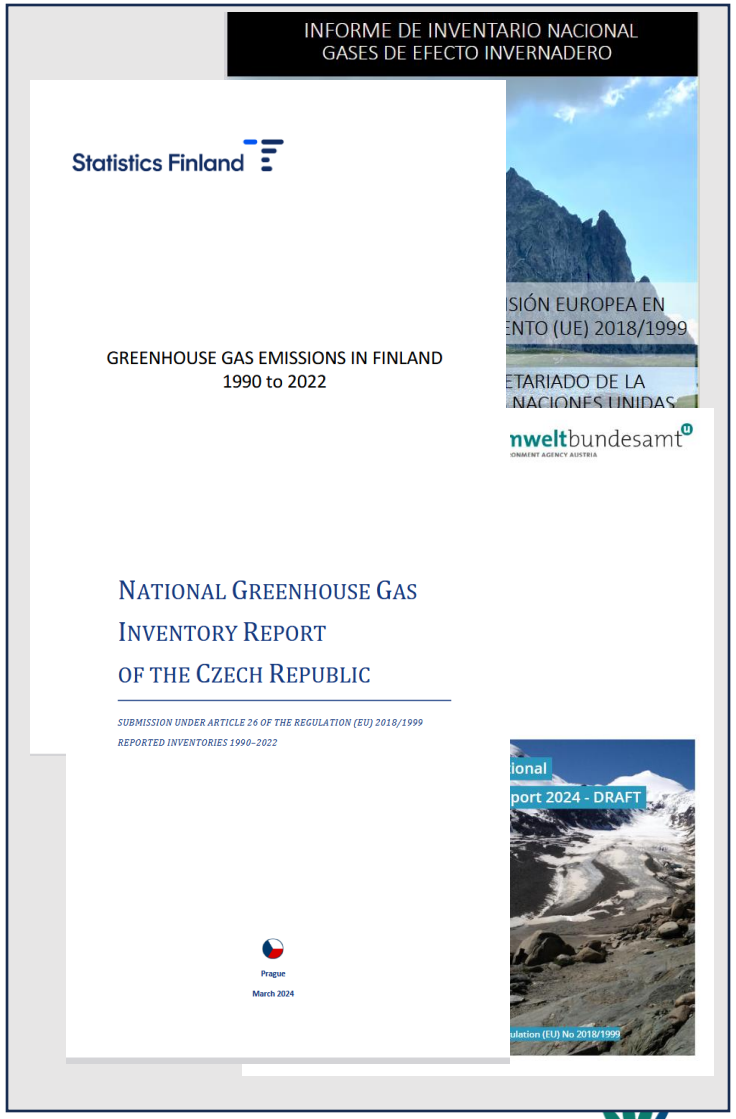
Final remarks

- **IACS data are increasingly central**, providing a robust and validated backbone for estimating GHG emissions and removals in the LULUCF sector.
- **Data reuse** within institutions should not be hindered by limited public availability — **internal collaboration is key**.
- Looking ahead, advancing **spatial data harmonisation, semantic consistency, and interoperability** will be essential to **strengthen LULUCF** inventories and reduce uncertainty

Better data and stronger collaboration will turn uncertainty into confidence for climate action



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Thank you for your attention

- Contact information:
  - rafal.zielinski@eea.europa.eu
  - lulucf@eea.europa.eu

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