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Cropland and grassland management data needs from existing IACS sources

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Executive summary

This report analyses the use of IACS and other datasets for reporting and accounting Greenhouse Gas (GHG) emissions and removals in the land use sector.

The land use sector comprises land use, land use change and forestry (LULUCF) as well as agriculture, jointly referred to as agriculture, forestry and other land use (AFOLU).

Decision 529/2013/EU of the European Council and the Parliament of 21 May 2013 brings the LULUCF sector in the EU emission accounting obligations. These new accounting obligations for EU member states are phased in over a period extending to 2022.

This Report, as part of work performed by the JRC for DG Climate Action under an Administrative Arrangement (AA), aims at exploring the usefulness for cropland management (CM) and grazing land management (GM) accounting of the vast amount of data already regularly collected on the EU level in the context of environmental and agricultural policies.

One of the most promising datasets to meet LULUCF reporting obligations is the "Integrated Administration and Control System" (IACS) that has been set up by all member states to manage the implementation of the Common Agricultural Policy, and its GIS, "the Land Parcel Identification System" (LPIS).

The data the LPIS holds are geo-referenced polygons of land parcels (units of management or production), and information on the type of land cover, as a minimum in terms of broad categories such as arable land, grassland, permanent crops, and broad families of crops, with their area (eligible hectares).

The LPIS is a pan-EU database that provides very detailed and accurate information on the status of agricultural land cover at any given time since 2005. The potential of the LPIS to efficiently track land use changes is derived from its pan-European semantic definition of agricultural land cover types, and the mandatory adequate update cycle of the dataset.

This study assessed other potential datasets, including Eurostat "Land Use/Cover Area Frame Survey" (LUCAS); the Farm Structure Surveys (FSS); the Farm Accountancy Data Network; CORINE Land Cover.

In this report, we have assessed more in detail the potential use of LPIS data for accounting of LULUCF emissions and removals with IPCC tier-2 and tier-3 methodologies. The assessment involve the following steps:

- Investigate the semantic correspondence between the IPCC concepts and IACS concepts, i.e., do both communities address the common agricultural reality in a compatible manner?
- If concepts do correspond, identify which elements are or could be already available in the LPIS to address IPCC LULUCF data needs;
- For corresponding elements, not currently present in the LPIS, assess how IACS/LPIS can act as an instrument to facilitate the capture of these elements, with key constraints to address.

The semantic analysis revealed a considerable degree of semantic correspondence between the IPCC land use categories and LPIS land cover classes at an aggregated level. The LPIS land cover class either completely matches the definition of the IPCC sub-category (1-to-1) or is its "specialisation" (resulting in one-to-many relationships). Only in a few isolated cases was there a partial match, with respect to some IPCC sub-categories of managed (sown) and natural (self-sown) grasslands.

Management and input factor categories cannot be directly derived from IACS/LPIS data but many, if not most, real world phenomena reflected in the IPCC methodology

correspond to the common CAP or environmental legal definitions. No terminology incompatibilty is found.

Among the various options to obtain data from IACS/LPIS, one cannot expect immediate off-the-shelf data availability for the purposes of LULUCF accounting. However, a very robust common EU framework exists, and the best option to cater for UNFCCC and KP reporting and accounting data needs is to use the existing infrastructure and processes of IACS to (a) collect the existing information, (b) combine and complement as needed with other datasets, and (c) create additional information. There are also varying ways that the member states have used to set up their systems. This can be considered as evidence of the scalability and flexibility of the IACS infrastructure to accommodate the specificities of the different EU MS, as well as of to allow the processing of the IACS data to serve different policy objectives.

Field-level data on practices could be collected from 2017 in parallel with the mandatory geospatial aid application, which in many member states is already implemented. In particular, a minor additional data collection could be annexed to the geospatial aid application, ensuring minimal efforts for farmers and authorities alike.

An assessment and estimation of costs to improve and adapt the IACS system has shown that this would be more cost-effective, in comparison to developing a stand-alone, separated system for LULUCF accounting purposes.

Whereas technical issues are surmountable, it would be necessary to address legal and other implementation constraints. Key aspects concern data access and data sharing. Authorities in charge of IACS are generally not the same as those responsible for reporting and accounting for the LULUCF Decision. It would be necessary to ensure that relevant land cover data held within IACS, including the LPIS, do not fall under privacy restrictions, so that third parties (e.g. statistical offices, organisations responsible for IPCC reporting and accounting) receive access for their tasks and obligations (e.g. for statistical purposes, monitoring and evaluation).

1. Introduction

1.1. Background

This report analyses the use of IACS and other datasets for reporting and accounting Greenhouse Gas (GHG) emissions by source and removals by sink in the land use sector[1].

The land use sector comprises land use, land use change and forestry (LULUCF) as well as agriculture, jointly referred to as agriculture, forestry and other land use (AFOLU).

World GHG emissions totalled 49 Gt of CO_2-equivalents (CO_2-eq) in 2010, according to the IPCC 5th Assessment Report. AFOLU accounts for about a quarter of these (24% of direct emissions and a little less than 1% of indirect emissions).

Globally, net emissions from the LULUCF sector alone account for 46% of all AFOLU. This is more than 11% of all global GHG emissions. In comparison, livestock and manure are responsible for 7.2% of global emissions, and the building sector for about 6.4%. LULUCF has a major role in GHG emissions but it also acts as a sink.

The World Resources Institute (2014) has estimated the potential for mitigation of various actions. It compared the level of emissions between the IPCC median baseline and the estimate IPCC median emissions needed for a 2°C pathway. By taking actions on degraded land and forests, the LULUCF sector would contribute at least a quarter of mitigation, which is on a comparable level with the mitigation potential of clean energy financing. This is even slightly more than what could be achieved with energy efficiency, and much more than carbon financing (*ibidem*).

In the EU, the LULUCF sector is actually already a net sink that removes from the atmosphere a significant share of total EU emissions of GHG. In the EU, current emissions from agriculture (i.e. CH4 and N2O from livestock, fertilisation and manure management) represent about 11% of total GHG emissions. Net removals[2] in the LULUCF sector compensate about 7% of current total EU GHG emissions. For this reason, the EU has deemed it important to increase its capabilities so that in future it can fully account for LULUCF.

Countries that are Annex I Parties to the UNFCCC are required to submit annual National Inventories Reports (NIR) on GHG emissions and removals. As far as LULUCF is concerned, these concern six land uses: Forest Land, Cropland (CO_2), Grassland (CO_2), Wetland, Settlement, and Other Land. Reporting under the UNFCCC is compulsory for all land uses, whereas for the purposes of the Kyoto Protocol (KP) accounting is mandatory only for Afforestation/Reforestation, Deforestation, and Forest Management.

Annex I Parties that are also Parties to the KP have additional reporting requirements and mandatory accounting of emissions and removals in respect to GHG emission reduction targets. All EU member states are Annex I Parties to the UNFCCC and its KP. In the framework of the KP, the EU has committed unilaterally[3] to reduce its internal overall GHG emissions by 20% below 1990 levels by 2020.

Emissions and removals of GHG from the LULUCF sector do not count towards the EU's 20% GHG emission reduction targets for 2020, pursuant to Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009. However, these emissions and removals do count in part towards the EU quantified emission limitations and reduction commitments pursuant to Article 3(3) of the KP. Decision 529/2013/EU of the European

[1] The results presented here are compatible with the outcomes of the 21st Meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and with the Paris Agreement reached on that occasion.
[2] Removals of CO_2 mainly by forests, with a smaller amount removed by agricultural soils.
[3] Already before the COP21 held in Paris in December 2015 and the Agreement reached there.

Council and the Parliament of 21 May 2013 has now included the LULUCF sector in the EU emission accounting obligations.

These new accounting obligations for EU member states are phased in over a period extending to 2022, following a two-step approach. A first step establishes robust common accounting, monitoring and reporting rules on how MS shall account for the various land use activities for the second commitment period (CP) of the KP (2013-2020). A second step will consider the formal inclusion of the sector in the EU climate commitment, once the EU implements a harmonised and robust accounting system.

1.2. Three-approach, three-tier IPCC accounting methods

There are three different approaches that are used to estimate land areas and changes in land area associated with LULUCF activities. These land-use and land-use-change approaches can be combined with three different tiers of emission estimates.

The term "approach" is distinct from the term "tier". The approaches are not presented as a hierarchy in the UNFCCC Good Practice Guidance of the IPCC for LULUCF reporting and accounting (GPG-LULUCF), although the requirements of Article 3.3 and 3.4 under the Kyoto Protocol imply the need for additional supplementary spatial data if approaches 1 or 2 are used for estimating and reporting on these activities. For accounting, in fact, the requirement is to assess and report spatially explicit changes.

The GPG-LULUCF provides advice on both UNFCCC Inventory preparation and Kyoto Protocol requirements.

All parties to the UNFCCC, for inventories, should follow six activity steps:

1. Use certain approaches to estimate land areas for each land-use category relevant to the country.
2. Estimate the emissions and removals of greenhouse gases for each land use, land-use change and pool relevant to the country by tier. A decision tree guides the choice of tiers. The hierarchical tier structure used in the IPCC Guidelines (Tier 1, Tier 2 and Tier 3) implies that higher tiers have increased accuracy of the method and/or emissions factor and other parameters used in the estimation of the emissions and removals.
3. If necessary, in some cases, collect additional data (if required to implement a particular tier) to improve emission factors, other parameters and activity data
4. Estimate uncertainties at the 95% confidence level
5. Report the emissions and removals
6. Implement QA/QC procedures

Additionally, Parties subject to art. 3.3 and 3.4 of the Kyoto Protocol[4] should assess if data assembled following these six steps can meet the supplementary data requirements and – if not – collect or collate any additional information necessary.

There are three approaches that can be used:

Approach 1: "Basic land-use data" uses area datasets likely to have been prepared for other purposes such as forestry or agricultural statistics. Frequently, several datasets will be combined to cover all land classifications and regions of a country. Determination of the area of land-use change in each category is based on the difference in area at two points in time, either with partial or full land area coverage. No specification of inter-category changes is possible under Approach 1 unless supplementary data are available (which would of course introduce a mix with Approach 2). The land-use distribution data is likely not spatially explicit.

Approach 2: "Survey of land use and land-use change" provides a national or regional-scale assessment of not only the losses or gains in the area of specific land categories but

[4] These are the countries typically referred to as "Annex I" countries.

what these changes represent (i.e., changes from and to a category). Thus, Approach 2 includes more information on changes between categories. The result of this approach can be presented as a non-spatially-explicit land-use-change matrix.

Approach 3: "Geographically explicit land use data" requires spatially explicit observations of land use and land-use change. The target area is subdivided into spatial units such as grid cells or polygons appropriate to the scale of land-use variation and the unit size required for sampling or complete enumeration. The spatial units must be used consistently over time or bias will be introduced into the sampling. The spatial units should be sampled using pre-existing map data (usually within a Geographic Information System (GIS)) and/or in the field and the land uses should be observed or inferred and recorded at the time intervals required.

There are three methodological tiers for estimating greenhouse gas emissions and removals for each source. Tiers correspond to a progression from the use of simple equations with default data to country-specific data in more complex national systems.

Tiers implicitly progress from least to greatest levels of certainty in estimates as a function of methodological complexity, regional specificity of model parameters, and spatial resolution and extent of activity data.

Tier 1 employs the basic method provided in the IPCC Guidelines (Workbook) and the default emission factors provided in the IPCC Guidelines (Workbook and Reference Manual). Tier 1 methodologies generally use activity data that are spatially coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.

Tier 2 can use the same methodological approach as Tier 1 but applies emission factors and activity data which are defined by the country for the most important land uses/activities. Tier 2 can also apply stock change methodologies based on country-specific data. Country-defined emission factors/activity data are more appropriate for the climatic regions and land use systems in that country. Higher-resolution activity data are typically used in Tier 2 to correspond with country-defined coefficients for specific regions and specialised land-use categories.

At Tier 3, higher-order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national to fine grid scales. These higher order methods provide, at least in principle[5], estimates of greater certainty than lower tiers and have a closer link between biomass and soil dynamics. Such systems may be GIS-based combinations of age, class/production data systems with connections to soil modules, integrating several types of monitoring. Pieces of land where a land-use change occurs can be tracked over time. In most cases these systems have a climate dependency, and thus provide source estimates with inter-annual variability. Models should undergo quality checks, audits, and validations.

1.3. Objectives of this report

Reporting and accounting of CM and GM opens new challenges for MS. This Report as part of work performed by the JRC for DG Climate Action under an Administrative Arrangement (AA) aims at exploring the usefulness for cropland management (CM) and grazing land management (GM) accounting of the vast amount of land cover and land use data already regularly collected on the EU level in the context of agricultural and environmental policies.

[5] There are cases where IPCC accepts the use of models to overcome the lack of inventory data. Models are notably based on various assumptions and the accuracy of their estimation is a function of their robustness and reliability.

In terms of LULUCF reporting requirements, the main challenges that MS have to face relate to the need for a consistent land representation system and for a complete estimation of carbon stock changes.

Countries have to ensure consistency among all the different data sources employed for land representation in order to meet the land balance principle (the sum of total reported areas has to match the total official area of the country and be constant in time).

In this respect, careful classification of CM and GM must be made, with potential difficulties in terms of definition and semantics due to different management practices (e.g. set aside land or crop rotation), and because of the methods used for data collection (e.g. land cover vs. land use; data collection by inventory vs. sample survey).

Sections 2 and 3 briefly describe the most relevant datasets, starting with the Land Parcel Identification System (LPIS), i.e., the Geographic Information System of the Integrated Administrative and Control System (IACS) of the Common Agricultural Policy.

Sections 4 provides detailed accounts of our analyses and a proposed methodology. Section 5 outlines future steps and highlights potential pitfalls, describing a proof-of-concept approach to test the methodology in selected member states that represent the different existing LPIS types.

2. The Integrated Administration and Control System and the Land Parcel Identification System

2.1 What is IACS / LPIS?

All EU Member States must set up and operate an "Integrated Administration and Control System" (IACS) to manage the implementation of the Common Agricultural Policy[6]. The IACS must include an identification system for agricultural parcels.

This is commonly named "the Land Parcel Identification System" (LPIS), although the legislation does not explicitly define such a designation. Considering the INSPIRE definition of GIS, the LPIS is the GIS of reference parcels and other spatial data, i.e., the single GIS within the IACS. Containing one-hundred and forty million reference parcels, its creation totalled an estimated workload of roughly seven-hundred and fifty men-years.

This LPIS must be established based on maps, land registry documents or other cartographic references. GIS techniques must be used, including aerial or spatial orthoimagery, with a homogenous standard that guarantees a level of accuracy that is at least equivalent to that of cartography at a scale of 1:10,000 and, as from 2016, at a scale of 1:5,000[7].

The LPIS is built around a set of reference parcels that:

- Are measurable;
- Allow unique and unambiguous localisation of agricultural parcels (land used by the farmer);
- Record the eligible agricultural area (land cover) they contain;
- Are stable over time.

A LPIS reference parcel acts as the unit of administration and control for the subsidy payment processes. It represents the stable maximum eligible area wherein agricultural parcels become annual units of declaration, inspection and payment .

The LPIS must contain a classification of stable land cover and/or land use units (the basis for eligibility for any scheme), plus the resulting "eligible hectares" value for all support schemes, area-related measures, landscape features subject to retention, Ecological Focus Area (EFA), and areas with natural constraints. Following the latest reform of the CAP, by 2018 at the latest it shall also contain separate spatial representation of stable EFA-elements.

The spatial character is explicit for:

- The agricultural parcel as the patch of land (area) declared by the farmer in a given year. Delineation was optional but becomes mandatory, from 2017 onwards;
- The reference parcel, which is always digitised and should hold stable land units with a validated agricultural area to which the agricultural parcels can be related;
- EFA-elements that are either land cover features (hedges, ponds, etc.) or practices remaining in place for longer than three years (e.g., strips, uncultivated margins).

Since 2009, the agricultural area could also include ecologically valuable landscape features such as ponds, hedges and trees. In fact, once these features became part of

[6] Pursuant to article 67 of Regulation 1306/2013 on the financing, management and monitoring of the common agricultural policy.
[7] Pursuant to article 70 of Regulation 1306/2013.

Good Agricultural and Environmental Condition (GAEC) and could not be removed anymore, they had to be accounted for in the LPIS, either spatially or alphanumerically.

In some EU Member States, the LPIS comprises also a spatial representation of these non-agricultural land. The spatial resolution and mapping accuracy of these might be inferior in comparison to those related to agriculture, but generally they can be considered equivalent at least to the cartographic scale of the CORINE Land Cover product (1:100,000).

Several options have emerged for the design of the LPIS system, but all options are compliant with the CAP legislation. Each Member State selects the option that is most suitable for its situation (and "hybrid" situations apply, too). Each design has specific consequences regarding processes and organisation of the LPIS but not for the key common functionality of identifying and monitoring the agricultural land and agricultural activity.

The five design options are:

1. Agricultural parcel.
   This is the vectorised annual production block representing the crop (group), sketched by the farmer. The visible orthoimage features acts as an implicit reference parcel boundary. This option requires good farmer input provisions, regular update of the imagery and good year-by-year handling and tracking of the parcels.
2. Farmer's block.
   This represents the (combined) agricultural parcels of a single farmer in a given reference year sketched by the farmer and validated by the administration. This option requires good farmer input, provisions for validation and regular update of the imagery.
3. Physical block.
   This represents the production units as visible in a reference year by the administration without consulting the farmer. This option requires the appropriate selection of the physical boundaries and a good internal organisation of the LPIS management.
4. Cadastral parcel.
   This identifies land by the unit of legal ownership of the land, provided by the cadastral institution. The type of agricultural land inside has to be determined separately. To be effective, this option requires that the ownership boundaries reflect the real land tenure. It demands good cooperation with, and appropriate setting of priorities by, the cadastral institution.
5. Topographical block.
   This is the unit of stable management found in the topographic maps provided by a third party, mostly the national mapping agency. In practical terms, a topographical block show the same characteristics as the cadastral parcel, i.e., a separate determination of the type of the agricultural land is needed. This option requires good cooperation with, and appropriate setting of priorities by, the national mapping agency.

There are forty-four LPIS systems (in some Member States the LPIS custodians are regional). Their chosen design options are shown in Table 1.

Table 1 – LPIS designs in EU Member States, as reported by the MS

LPIS types	Total	Member states using this option
Agricultural parcel	5	BE-FL; DE-HE; DE-SL; LU; MT
Farmer's block	11	AT; CZ; DE-BA; EE; FI; FR; HR; IE; PT; SE; SI
Physical block	18	BE-WL; BG; DE-BB; DE-LSA; DE-MV; DE-NI; DE-NRW; DE-SH; DE-SN; DE-TH; DK; EL; HU; LT; LV; NL; RO; SK
Cadastral parcel	6	CY; DE-BW; DE-RF; ES; IT; PL
Topographical block	4	UK-EN; UK-NI; UK-SC2; UK-WA

Many systems show some degree of hybridisation, combining properties of two LPIS types. Hybrids are not a problem per se. For instance, if physical boundary markers are present in the field, cadastral boundaries can subdivide a large physical block. Technically, any hybrid is in principle acceptable if the MS demonstrates and validates spatial compatibility of composing datasets and if the combination of concepts leads to a closer approximation of the agricultural parcel or unit of land use. Similar considerations can apply to aggregation processes where e.g. individual cadastral parcels should be merged into measurable "basic property units" to reflect stable units of actual land tenure.

The LPIS main role is to register eligibility of land for area aids. The key condition for eligibility is developing agricultural activities. INSPIRE identifies two approaches to defining land: land cover and land use. The CAP addresses both.

Land cover concerns the physical and biological cover of the earth's surface. This concept is at the basis of the wording in the Regulation that refers to land "under arable crops, permanent crops and permanent grassland".

Land use characterises the territory according to its current and future planned functional or socio-economic purpose. This is the crop group eligible for area payments in the (annually) declared agricultural parcel.

Land cover does not directly involve human activity or use. It is the most straightforward concept. It can unambiguously describe the earth's surface. An international classification exists and is sufficient to cater for diversity across Europe. Land cover constraints the land use options (one cannot plough in a forest). Hence, agricultural land cover expresses the potential for eligibility of CAP payments.

Land use is a more complex concept. In any given year, there could be several different uses of a particular grassland, such as for grazing, mowing, camping, hunting, various types of public events, and so forth. All of these require a given human activity for a given time and may or may not generate revenue. An agricultural parcel is the declaration of agricultural activity inside the reference parcel for payment in a given year. This is a clear expression of land use.

The mapping requirement for LPIS reference parcels clearly favours the land cover concept because of its exhaustive classification and inherent stability. The land use aspects have not always been mapped but they have at least been stored in IACS as an attribute. With the introduction of the mandatory geospatial aid application from 2017 onwards, both concepts will have explicit spatial representation in all systems.

In LPIS, the eligibility potential (maximum eligible area) is always determined on a land cover basis. MS employ land cover to describe the types of land that they consider potentially eligible. This catalogue or legend is referred to as the eligibility profile.

The farmer annually declares area under actual agricultural land use. This declaration serves as the basis for payment and is therefore carefully controlled by an elaborate system of on the spot checks (OTSC). Every year, MS Administrations inspect or re-measure a minimum of five percent of the declarations. For incorrect area declarations, financial reductions and penalties apply. These intensive and numerous OTSC procedures,

in combination with a dedicated quality assessment of the reference parcels, make IACS/LPIS by far the most assured dataset in the land cover / land use domains.

2.2 A description of data in the LPIS

The data the LPIS holds are geo-referenced polygons of land parcels (units of management or production), and land cover, as a minimum in terms of broad categories such as arable land, grassland, permanent crops, and broad families of crops, with their area (eligible hectares).

For the agricultural parcels, most systems, if not all, apply a crop code that can hold even a very large number of different crops (300 different crop codes in the common Eurostat catalogue of crops).

The LPIS, or IACS in general, though, does not generally contain data on agricultural practices (corresponding to the "activities" in IPCC methodologies, such as, e.g., tillage, low-tillage or no-till cropland management) where such data are not related to payment conditions.

Any LPIS has spatial attributes (such as, e.g., boundary coordinates and areas) as well as alphanumerical attributes (such as, e.g., unique identification codes, maximum eligible hectares). All spatial data is stored and maintained in the national coordinate reference system. From 2015, the spatial resolution of the system should be gradually upgraded from a scale of 1:10 000 to 1:5 000. Many LPIS already operate at that scale.

The reformed CAP also extends the definition of permanent grassland, which hitherto allowed only area covered with grasses or other herbaceous forage (not included in the crop rotation for 5 years or more) to be considered as grassland. The new article 4.1(h) of Regulation 1307/2013 states that grassland may include other species such as shrubs and/or trees that can be grazed, provided the grasses and other herbaceous forage remain predominant. In addition, member states may decide to consider as eligible for grazing areas where grasses and other herbaceous forage are traditionally not predominant, providing that such areas of land can be grazed, and provided that they form part of established local practices. Those areas are called "permanent grassland under established local practices (PG-ELP)" and must also be accounted for in the LPIS.

Thus, the new CAP reform broadened the role and territorial coverage of the LPIS, strengthening its potential for environmental monitoring, by introducing practices (EFA) and extending into extensive grasslands.

Depending on the type of reference parcel implemented by a given EU MS Administration, the spatial information related to the eligible agricultural land can be stored by more than one spatial theme, thus represented by more than one layer. LPIS based on production block (homogeneous and continuous unit of agricultural land) usually had only one theme; each reference parcel represented by a single polygon of pure agricultural area. Systems based on topographic block (unit of land holding agriculture and non-agricultural land) however have usually at least two spatial themes, one identifying the unit or the land, and one delineating the (eligible) agricultural area therein.

Although not explicitly required by the previous regulation (in force until 2013), many LPIS implementations operated a detailed inventory of the different agricultural land cover types within the agricultural area. The new CAP requires that at least a distinction between arable land, permanent grassland (PG) and permanent crops, as the main agriculture categories, be made in all LPIS.

This distinction should be done in two ways depending on the situation:

- By alphanumerical recording of the types and the corresponding area values as attributes of the reference parcel (RP);
- By delineation (assigning geometries to each type within the RP).

2.3 Potential of the IACS/LPIS to track land-use changes

From the point of view of environmental monitoring, the LPIS is a pan-EU database that can provide very detailed and accurate information on the status of agricultural land cover at a given time. Assessments performed by the Joint Research Centre in the recent past (2009-2010) show that geospatial information stored in the LPIS corresponds well to what a large-scale land cover (at a scale of 1:5 000 to 1: 10 000) should represent. This is particularly valid for LPIS implementations such as in Bulgaria and Romania where, due to specific EU accession conditions (Art. 124 of Regulation 73/2009 allowing dynamics in the Utilised Agriculture Area), the LPIS thematic data does not only cover all agricultural land, but actually covers the whole territory.

An annual LPIS quality assessment reports a high degree of LPIS thematic accuracy. This QA enables LPIS custodians to implement a quality policy and take appropriate remedial actions. This triggered most National Administrations to implement a rigorous update cycle. These facts make the LPIS a very good candidate as a source of information with respect to LULUCF reporting. The original spatial and thematic data might be too detailed in order to be used as a direct input for IPCC reporting requirements. A bottom-up approach for data aggregation, through semantic mapping and up-scaling of LPIS data, should be implemented.

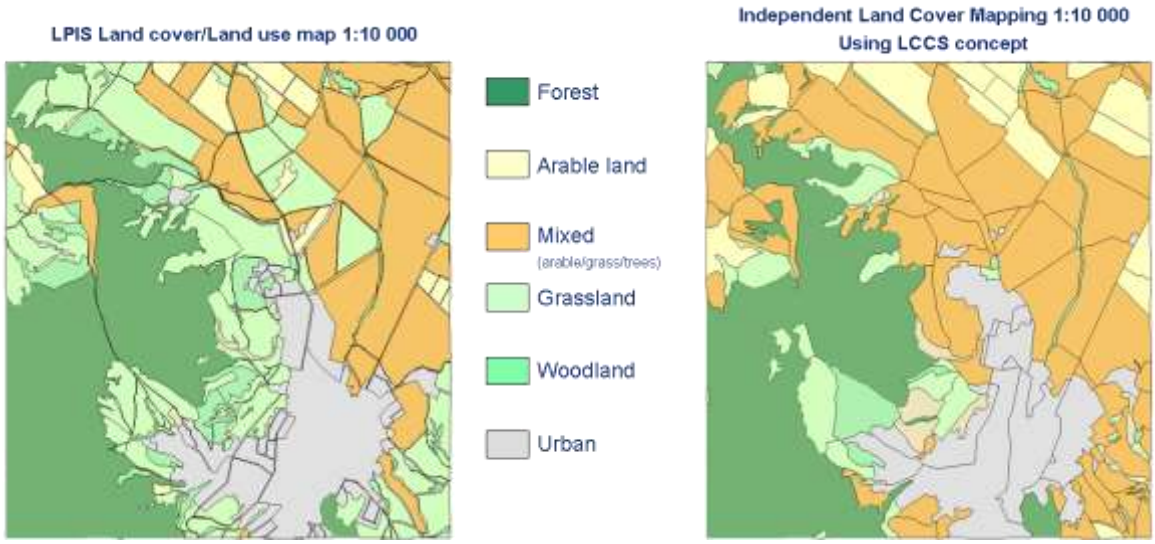

Figure 1 – Comparison between LPIS data and large-scale land cover map. Source: DG JRC, LPIS Workshop, Sofia, 2008

The following two key characteristics provide for the potential of the LPIS to efficiently track land use changes:

1. The unequivocal and correct semantic definition of agricultural land cover types, especially sensitive in the case of grasslands; and

2. The adequate update cycle of this thematic information.

Regarding the semantic definition, the need to provide adequate monitoring of farming aids and necessary controls of the performance of the IACS (and its GIS, the LPIS) already called for the elaboration of an "identity card" of agricultural land. This provides the methodological framework to determine the nature of each land type, based on biophysical conditions (land cover). This must be done in such a way that it is equally delineable from both orthoimagery and field inspections. To create such an identity card, the agricultural land cover has to be characterised independently from both data capture method and local

semantics. The JRC developed such an approach based on the TEGON model. This has been developed in-house, in line with the ISO19144-2 (Land Cover Meta Language) standards.

The TEGON concept was further tested in practice within the cross-border project SPATIAL. It was considered as one of the few major testbed of spatial data harmonisation using an INSPIRE framework. A key output of the project was a reference land cover dataset for the cross-border region between Bulgaria and Romania, derived though integration of LPIS and EO data from Copernicus, and the subsequent upscaling to 1:25,000 mapping scale.

Concerning applicability of the update, the cycle for a complete systematic update of the LPIS is often set to three years, the typical period for a complete coverage of a Member State with new orthophotos. Some EU Member States have a shorter, even yearly update cycle. In reality, in most if not all MS, each year one third of the territory covered by the LPIS is updated. Notably, the use of orthoimagery is only one of the sources for LPIS update. Farmer declarations, on-the-spot checks, third-party datasets, etc., all contribute to providing input to the update. Although the LPIS design might differ from country to country, all LPIS systems must store historical and archive data.

Given the purpose for which the LPIS has been set up and is maintained, additional processing and tuning (semantic mapping, aggregation, synchronisation of time stamps) is needed in order to extract LU change data necessary for LULUCF accounting. Our results show that this can be achieved in a cost-effective manner.

Some LPIS implementations might have partial deficiencies with respect to the spatial representation and change detection of different agricultural types. Currently, also as a result of the recent CAP reform, MS Administrations need some time to upgrade their LPIS completely in order to ensure the complete availability of some of the thematic data. Some EU Member States might rely on external sources to complement the information. External sources may include, e.g., detailed land cover inventories and spatial data collected in the frame of pan-European projects. All this will be achieved well ahead of the 2021 campaign when LULUCF accounting obligations under Regulation 529/2013 will be fully enforced.

There are two general considerations on the LPIS that must be considered.

Firstly, the LPIS may, at least where it is implemented in the farmer block design, only include the land of farmers who apply for CAP support. However, the proportion of professional farmers that choose to eschew the direct aids is obviously very low.

Secondly, the LPIS does not necessarily cover all possible agricultural practices considered by IPCC given the fact that some semi-natural lands (e.g., certain rough grazing, forest pastures or wet meadows) are not considered eligible. However, since these land uses are often edaphically constrained and/or protected by environmental measures, the proportion that would change into another land cover class is expected to be very low. Hence, we consider that this aspect has no impact on LULUCF reporting.

These two considerations do not affect the usefulness and usability of LPIS for KP accounting. If doubt remain, samples can be used such as it is done in the case of forest inventories.

3. Other relevant datasets

Various statistical data already collected for other purposes can feed into the assessment of LULUCF emissions and removals. Statistics on various levels from European to local might complement other assessments, e.g. those based on IACS / LPIS data.

This chapter summarises the content and characteristics of available datasets and assess their potential and limits for LULUCF accounting.

3.1 A summary overview of available data

3.1.1 Eurostat data, Land Use/Cover Area Frame Survey (LUCAS)

The LUCAS project started in May 2000, based on a decision of the European Parliament and the Council. LUCAS aims at developing a standard survey methodology to estimate the area under different land use or land cover types in order to obtain harmonised estimates on the EU level.

LUCAS contains data on land cover and land use for four years (2003, 2006, 2009, and 2012). The 2012 survey also contains data on topsoil (Coarse fragments, Particle size distribution, Clay content, Silt Content, Sand Content, pH(CaCl2), pH(H2O), Organic carbon) from samples collected by the JRC in 10% of the points.

The metadata notes state that comparisons over time should be avoided because of the changes in total coverage and the amendments introduced in the classification for the 2012 survey.

Quoting from the Eurostat Metadata document (Eurostat, 2010, 2013), section 16.2:

"The LUCAS Survey is designed in order to achieve harmonisation and comparability among campaigns; however for the time being comparability over time for estimates related to areas < 500 Km2 should be avoided, especially within strata with a limited coverage, due to the changes in the total coverage, the amendments introduced in the classification for the 2012 survey and the time that has elapsed since the first phase sample was stratified (see chapter 20.5 Data compilation).

A summary of the procedures implemented to optimise the comparability between 2009 and 2012 survey is reported […]. The procedures impact the statistical tables disseminated and not the primary data published in the LUCAS dedicated section.

Eurostat is revising the series in order to ensure better comparability over time after results of 2015 Survey will be available."

For LULUCF reporting, it is one of the main drawbacks of LUCAS data that tracking land use changes over time has explicitly been avoided by survey design.

3.1.2 Farm Structure Surveys (FSS)

The Farm Structure Surveys (FSS), also known as "Surveys on the structure of agricultural holdings", is carried out every 2-3 years as a sample survey in all EU Member States. It is also carried out as a census every ten years. A common methodology is consistently applied throughout the EU on a regular basis, providing comparable and representative statistics across countries and time, at regional levels.

Member States collect information from individual agricultural holdings and forward them to Eurostat (respecting confidentiality constraints[8]).

Agricultural holdings are the basic units, defined as technical-economic units under single management that are engaged in agricultural production. The FSS covers all agricultural holdings with an utilised agricultural area (UAA) of at least one hectare (UAA ≥ 1 ha). It also covers any holdings of less than one hectare of UAA in case their market production exceeds given economic thresholds.

[8] Where (a) the number of individual records used for the calculation of the cell is too small, and (b) the two individual records with the highest values represent at least 85 per cent of the cell value, the cells are flagged for confidentiality. When compiling tables, filters are applied to those cells. These filters are: (i) dominance treatment: if any holding accounts for at least 85% of the value, this is put to zero; (ii) small number of units: if a value is calculated from less than 5 holdings, this value is put to zero; (iii) rounding: values are rounded to the closer multiple of 10.

Comparability across surveys years is somewhat limited. Surveys have changed some methodological aspects as from 2005, mainly to adjust to legislative changes. Surveys in 2007 provide data for both the past and current methodologies and geographical coverage. Data directly available from Eurostat for post-2005 surveys is aggregated by Member State. Moreover, surveys happen every 2-3 years only, hence not allowing year-on-year comparison.

The following data are available:

- Farmland: number of farms and areas by size of farm (UAA) and NUTS 2 regions;
- Land use and area (crops); Main crops;
- Livestock;
- Farm Labour Force (including age, gender and relationship to the holder)
- Economic size of the holdings
- Type of activity; other gainful activity on the farm; system of farming;
- Machinery;
- Organic farming.

Until 2007, in certain cases or for some variables only, data is available down to NUTS-3 level, but overall data is mostly available on NUTS-2 level. In fact, in some Member States and for most years, and in particular the LULUCF base year 1990, Eurostat data is aggregated on NUTS-1 level. In many cases, two thirds or more of the cells have missing values for the year 1990 and almost half of the cells have missing values for the year 2000, with just less than 15% of cells still having missing values for 2007.

For some countries and for certain reporting periods, the permanent grassland that is part of the common land of a municipality or village is not properly accounted through the FSS.

3.1.3 Farm Accountancy Data Network

The Farm Accountancy Data Network is an instrument to evaluate the income of agricultural holdings and the impact from the CAP. Launched by Regulation 79/1965[9], it consists of annual surveys of a sample of farms representative across the three dimensions of region, economic size and type of farming.

The sample consists of approximately 80,000 holdings taken from an EU population of five million farms that are larger than a certain economic size[10]. These agricultural holdings account for about 90% of the total agricultural production in the EU and cover about 90% of all EU utilised agricultural area.

Among the approximately one thousand variables collected, physical and structural data available include location, crop areas, livestock numbers and other structural characteristics. "Farm Returns" provide data collected according to well-defined rules and definitions. The variables have a financial flavour, consisting mostly of monetary values. While data on utilised agricultural area (UAA) are present, as well as other area values, it is not straightforward to differentiate UAA in terms of types of crops.

A committee formed by the Commission and the Member States defines the precise content of the data. The current revision[11] has been issued in February 2012.

More precisely the dataset includes the following data that bears some relevance to the LULUCF scope:

[9] Now Regulation 1217/2009, which repealed 79/1965.
[10] The economic size of a holding is the total standard output of the holding expressed in Euro and defined pursuant to Regulation 1217/2009 and Regulation 1242/2008.
[11] Based on Regulation 868/2008 as amended by Regulation 781/2009.

- A unique farm identifier;
- A code for the location of the farm at the finest geographical unit possible (preferably parish or municipality);
- The type of farming according to the Community Typology Regulation[12];
- Whether the farm is conventional, organic, or in conversion;
- The location, or not, in less-favoured areas of the majority of UAA, specifying whether in mountain areas or not;
- Hectares of irrigated UAA (not under glass);
- Whether the majority of UAA is situated in an area eligible for Natura 2000 payments or payments linked to Directive 2000/60/EC;
- Number and value of livestock;
- Costs (at current value) of various inputs, among which of key relevance for LULUCF accounting:
    - Fertilisers and soil improvers;
    - Crop protection products;
- Specific forestry costs;
- Valuation of land, buildings and rights, specifically detailing, inter alia, agricultural land, permanent crops, land improvements, as well as forest land including standing timber. It should be noted that this is provided in terms of monetary value, not necessarily detailed as area values;
- Grants and subsidies received, with a detailed differentiation among types of subsidies.

In addition to structural data as indicated above, production data is also recorded in the farm return tables, for a very detailed list of different crops. Crop area is in principle also given. Area is not recorded for livestock products, processed products, by-products, and for stocks from the previous accounting year if the crop is not cultivated during the current year.

3.1.4 CORINE Land Cover

In 1989, the European Commission launched CORINE Land Cover (CLC), an experimental programme to harmonise a wide range of environmental themes as water, air and land. Its approach was based on integration of existing national datasets. However, in the case of land cover the project concluded that national datasets were too diverse to attempt harmonisation. Instead, CORINE developed a specific 44-class legend and on this basis launched several EU-funded mapping initiatives (CORINE, 1994). The national mapping producers engaged in CLC are allowed to "enrich" the nomenclature with more detailed, country-specific classes, providing that the pre-defined structure of the class hierarchy is preserved.

CLC soon comprised the whole of Europe[13], as well as (parts of) other continents. Three updates for Europe have been made to date. Its land cover mapping was so successful that the name CORINE became synonymous for this one theme, long surviving the original, much broader experimental project. Despite this success in producing pan-European datasets, many EU MS considered the methodology, even customised, too general for national or regional applications. Therefore, MS created and maintained separate national land cover datasets.

[12] Regulation 1242/2008
[13] Only CLC 2000

The most frequent criticisms on CLC relate to its minimum mapping area, to the inclusion of land use concepts in some class definitions, and to an insufficient number of classes available for an accurate mapping of territories and conditions that were different from those where the original legend was developed.

To overcome some of these deficiencies, EEA launched a call for the elaboration of methodology for the production of a new CLC inventory through upscaling the national land cover inventories in line with CLC product requirements. This also includes an option for population (enhancement) of existing CLC polygons with detailed and harmonised thematic data from the national land cover datasets. The project has been awarded to the Eionet Action Group on Land monitoring in Europe (EAGLE) and it has been recently finalised. Apart from expected benefits in relation to the quality of CLC data, the project is expected to support better harmonisation of national land cover mapping activities all over Europe.

3.1.5 Other data sources

A FP7-funded project, HELM (Harmonised European Land Monitoring), conducted a comprehensive overview of land monitoring programs and strategies of European countries (EU member states and countries of the European Economic Area). Project deliverables provide a well-structured inventory of the national land cover/land use datasets elaborated and maintained by the different national mapping authorities as well as by other public and private actors.

Another noteworthy source of information on relevant datasets is the portal of the Danube Reference Data Service infrastructure (DRDSI) managed by the JRC. The portal includes a specific category related to irrigation and agriculture. The scope of the portal is however limited to the European countries that belong to the Danube Catchment Area. The portal is still in the phase of organising all relevant metadata for the available datasets so the information was still incomplete at the time of writing. Anyway, there are already some interesting examples of cross-border harmonised datasets and methods (LUISA, CBC SPATIAL, OneGeology). One of the objectives of the platform is to overcome the semantic and thematic differences between countries that are part of the European (Macro-Regional) Strategy for the Danube River.

3.2 IACS data vs. other available datasets

3.2.1 Agricultural area values

Among all the different data sources presented above, the combined cropland and grassland area values for Europe vary. In fact, each reflects the effects of the methodology used to compile the pan-European dataset.

Table 1 - Comparison of land-use statistics from various datasets

Member State	Total area (km^2) of LPIS reference parcels holding agricultural land	Total (km^2) declared area within LPIS reference parcels	Total (km^2) agricultural area estimated from the LPIS data	Total (km^2) agricultural land area (Eurostat, 2013)	Estimated (km^2) CLC2012 agric. area in line with CAP definitions (incl. natural grassland & agro-forestry)
Belgium	14,804	13,410	15,250	13,502	16,932
Bulgaria	42,563	41,277	42,563	56,090	63,927
Czech Rep.	35,570	35,552	37,931	50,764	38,987
Denmark	26,410	25,848	26,410	29,222	32,979
Germany	171,062	168,933	173,792	183,052	204,832
Estonia	9,845	9,653	10,298	12,294	14,692
Ireland	45,154	44,725	47,717	52,780	56,406
Greece	49,876	46,399	49,876	50,625	62,561
Spain*	232,650	232,069	232,650	300,422	222,925
France	276,960	276,738	295,250	292,644	341,558
Italy	95,447	79,221	95,447	159,338	170,864
Cyprus	1,685	1,617	1,685	1,238	4,672
Latvia	18,011	17,291	18,011	30,588	25,518
Lithuania	32,454	27,368	32,454	31,254	40,638
Luxembourg	1,248	1,201	1,282	1,378	1,400
Hungary	58,496	53,360	58,496	70,488	62,050
Malta	91	91	97	120	162
Netherlands	18,827	18,074	18,827	20,089	25,865
Austria	25,980	25,980	27,718	58,158	31,877
Poland	144,267	141,772	144,267	164,875	186,987
Portugal[$]	29,152	27,255	29,152	46,257	44,129
Romania	132,215	102,176	132,215	146,614	142,907
Slovenia	4,745	4,619	4,928	9,022	7,305
Slovakia	19,615	18,263	19,615	30,671	28,930
Finland	22,961	22,954	24,490	57,867	29,031
Sweden	30,299	30,172	32,190	64,244	41,197
UK[§]	164,116	113,655	164,116	187,260	143,741
EU-27	**1,704,503**	**1,579,673**	**1,736,727**	**2,120,856**	**2,043,072**

[§]UK, LPIS data exclude, other data include, Guernsey and Jersey Islands; [$]PT, LPIS data exclude, other data include, Madeira and Azores Islands; *For ES, data for Andalusia are based on CLC06

3.2.2 Some strong points for IACS/LPIS in the LULUCF domain

IACS/LPIS were set up to address the needs of the Common Agricultural Policy.

Each Member State made its own implementation choices. This may suggest that isolated and standalone systems have emerged. This perception, however, is false.

IACS/LPIS has some distinct advantages over many other potential LULUCF data sources:

- The large-scale spatial component is inherent in the design
- The spatial data and infrastructure of all Member states are based on common, pan-European semantics
- LPIS data on land cover and land use are subject to intensive and wide-ranging control processes
- Processes for data entry and information output are very similar for all systems, as they are designed to meet a single functional requirement.
- The LPIS update cycle is shorter than many if not all small-scale land cover inventories
- Past record and transaction archiving is assured.

None of the alternative existing datasets offers such characteristics.

4. A proposed approach to use the LPIS for LULUCF Accounting

The focus of our analyses is to investigate the use of LPIS data for accounting of LULUCF emissions and removals with IPCC geographically explicit approach-3 land-use data representation, combined with tier-2 and tier-3 methods. LPIS is a promising dataset for this purpose. It provides a quality-checked solution to the IPCC-related need to "identify and track land" over time. Starting with the 2017 campaign, IACS may also provide more information to feed into IPCC requirements with the geo-spatial aid application (GSAA).

Our assessments involved the following steps:

- Investigate the semantic correspondence between the IPCC concepts and IACS concepts, i.e., do both communities address a common agricultural reality in a compatible manner?
- If concepts do correspond, identify which elements are (or could easily be) already available in the LPIS to meet IPCC LULUCF data needs;
- For corresponding elements, not currently present in the LPIS, assess how IACS/LPIS and its supporting infrastructure may act as an instrument to facilitate the capture of these elements, with identification of key constraints to address.

We recall that IACS/LPIS data records the eligibility of land for CAP payments, which is the basis of annual farmers' aid applications and subsequent control. It does this by reflecting the current situation for a given year. Eligibility of land is based on pan-European definitions of land cover classes. By contrast, cross-compliance measures and EFA-elements are defined by the individual member-state authorities within a generic pan-European framework.

4.1. Setting the scene: IPCC requirements

In order to use data for LULUCF accounting, we firstly introduce the context and set the starting point by briefly describing IPCC requirements. We then move on to define the concepts, and to assess data semantics of what IPCC on one side and IACS/LPIS on the other side intend as land use and land use change. The focus here is on cropland management and grazing land management. We shall refer to the IPCC basic concepts for GHG reporting.

The equation below comes from from page 2.30 of chapter 2 of IPCC 2006 (equation 2.25 in the guidelines) and estimates soil organic carbon (SOC) for mineral soils. It summarises the IPCC data requirements.

$$SOC = \sum_{c,s,i} (SOC_{REFc,s,i} * F_{LUc,s,i} * F_{MGc,s,i} * F_{Ic,s,i} * A_{c,s,i})$$

where the factors multiplying the area of land $A_{c,s,I}$ depend on land use (F_{LU}), management (F_{MG}), and inputs (F_I). In the equation, *c* represents the climate zones, *s* the soil types, and *i* the set of management systems that are present in a country or region.

Annual change in carbon stocks in mineral soils, measured as tonnes of carbon per year, is computed as the difference of soil organic carbon stock in the last year of an inventory period with the soil organic carbon stock at the beginning of the inventory period, taking into account the time for transition between equilibrium SOC values[14].

[14] This is commonly 20 years, but it depends on assumptions made in computing the factors F_{LU}, F_{MG} and F_I. The detailed guidelines go beyond the scope of our analysis and the interested reader can refer to the cited IPPC document.

Soil organic carbon ($SOC_{REF\ c,s,i}$)

The default reference soil organic C-stock for mineral soils (0-30cm) indicated as SOC_{REF}, is expressed in, tonnes C ha^{-1} (given in Table 2.3 of IPCC 2006) and is calculated for a combination of soil type and climate region.

This soil characteristic plays no role in the direct payments. IACS/LPIS hold no relevant data, hence this concept will not be analysed further. Suffice to note that IACS/LPIS could provide geolocalised land cover data that may then be used with local data on SOC.

Land Use factor ($F_{LUc,s,i}$)

UNFCCC land use categories "Cropland" and "Grassland" only broadly correspond with land areas qualifying for LULUCF "Cropland Management" (CM) and "Grazing Land Management" (GM) for accounting purposes. There is a conceptual difference between the vocabularies of UNFCCC and IACS/LPIS; however it is easily resolved. The UNFCCC "land use" categories are in fact resembling land cover categories. In LPIS terms, in line with established practice and INSPIRE, land use refers to socio-economic use of land (e.g., cropping, grazing, forestry, settlements), whereas land cover refers to the bio-physical coverage of land (e.g., agricultural land, forests, permanent grassland and pastures).

Furthermore, IPCC defines land use also as "the type of activity being carried out on a unit of land." In IACS, the spatial unit of (agricultural) activity declared by the farmer is represented by the "agricultural parcel".

In the IPCC "Good Practice Guidance for LULUCF reporting and accounting" (GPG-LULUCF), the term "land use" is applied to broad land-use categories. It is recognised that these land categories are a mixture of land cover (e.g., Forest, Grassland, Wetlands) and land use (e.g., Cropland, Settlements) concepts. In IACS, their spatial representation corresponds to the LPIS reference parcel and the farmer's application agricultural parcel, respectively.

Area ($A_{c,s,i}$)

Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories deals with AFOLU, and its Chapter 4 details the methodologies applicable to the various land-use categories. It provides methods to estimate soil carbon for land remaining in the same land-use category as well as for land conversion to a new land use. As direct payments to agricultural holdings are essentially an annual process, this temporal dimension has not been the focus of the LPIS/IACS data. Nevertheless, its essentials lay implied in the results of past update activities and the required traceability thereof.

Referring to LULUCF, in these analyses we focus on grassland and cropland only. As summarised in section 1.2, emissions by source and removals by sink are estimated using one of three approaches combined with emission estimated at one of the three tiers of increasing complexity and accuracy. The fundamental steps to move towards approach 3 and tiers 2 or 3 involve first of all assessing the semantics of IPCC and IACS/LPIS and seeing what IACS/LPIS can provide as "candidates" to fulfil IPCC requirements. Secondly, it is necessary to highlight the criteria for implementation of IACS/LPIS data for LULUCF accounting. Finally, the analysis must address data availability, both current and potential.

Management factor ($F_{MG\ c,s,i}$)

IPCC factors directly describe the various categories that compose them for a given land use type. For the purpose of the semantic analyses below, we have formulated a working definition of the concepts behind the IPCC descriptions:

- For cropland[15]: intensity of soil disturbance (tillage);

[15] More precisely, for cropland IPCC subtype "long-term cultivated".

- For grassland: state of grassland degradation and improvement.

Soil disturbance and grassland degradation are concepts that are relevant in IACS/LPIS.

Input factor ($F_{I\ c,s,i}$)

As with the management factor, we propose the following working definition:

- For cropland: material exchange of carbon in the form of crop residue and/or manure;
- For grassland: presence of any additional management factor activity for improvement of grasslands.

Crop residue and manure are concepts that are relevant in IACS/LPIS. For grassland, no new concepts need introducing, as the input factor is merely a quality of the management factor above.

4.2 Semantic analysis of IPCC and IACS/LPIS concepts

4.2.1. The land-use factor (F_{LU})

For emission accounting in cropland and grazing land management, we have to consider what IPCC defines as "activities", i.e. management of land. For cropland, the IPCC considers all activities "human induced" (cropland is always managed). This is why cropland management has precedence[16] over grazing land management.

In IACS/LPIS, eligibility for annual payment of the direct aids are by definition subject to an agricultural activity by the applicant, so the scope of both domains corresponds.

IACS definitions

As described in section 2.1, IACS/LPIS contains land cover data categorised as arable crops, permanent crops and permanent grassland. The following definitions are given in Regulation (EC) 1307/2013:

"Agricultural area" means any area taken up by arable land, permanent grassland and permanent pasture, or permanent crops. It also includes arable land under mobile or fixed cover, or greenhouse.

"Arable land" means land cultivated for crop production or areas available for crop production but lying fallow, including areas set aside.

"Permanent crops" means non-rotational crops other than permanent grassland and permanent pasture that occupy the land for five years or more and yield repeated harvests, including nurseries and short rotation coppice.

"Permanent grassland and permanent pasture"[17] means land used to grow grasses or other herbaceous forage[18] naturally (self- seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more. This may include other species such as shrubs and/or trees that can be grazed, provided that the grasses and other herbaceous forage remain predominant. Where Member States so decide, it can also include land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas.

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[16] Pursuant to article 3.4 of the Kyoto Protocol, Annex I Parties must decide both which additional activities to add to the accounting of national commitments and how to add them.
[17] These are together referred to as "permanent grassland" in the legislation and in this report.
[18] "Grasses or other herbaceous forage" means all herbaceous plants traditionally found in natural pastures or normally included in mixtures of seeds for pastures or meadows in the Member State, whether or not used for grazing animals.

There are some areas of land that might be defined differently under IPCC and LPIS, e.g. non-permanent or temporary grassland (sown grass). These are mostly categorised as arable land in LPIS and should refer to cropland management. There is a clear necessity, once using data, to assess this aspect in more detail. As far as temporary grassland, other grazing and hay land, sown grasses and the likes, there might be differences between IPCC and LPIS semantics. This can also be different in different member states and should thus be analysed with care. Nevertheless, this is not a major obstacle to using IACS/LPIS data.

Land Use factor assessment methodology

In order to assess the potential semantic correspondence between the IPCC land use categories and the land–related information in the LPIS, the following approach has been implemented:

1. The definitions for cropland and grassland given in Sections 3.3 and 3.4 of the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, were analysed with respect to the different agricultural land cover types they refer to;

2. A set of mutually exclusive land cover types were derived from the text for each of these two categories;

3. For each of these agricultural land cover types (IPCC sub-categories), the minimum set of keywords (classifiers) that unambiguously defines the given land cover type were extracted;

4. The given land cover type was modelled with the Land Cover Classification System of UN-FAO, using the keywords and their ontology relationship. An LCCS-compliant codification (LCCS class) for each land cover type was generated;

5. Each LCCS class was compared with the list of the core agricultural land cover types present in the LPIS, provided in the same LCCS-compliant form. The list of agricultural land cover types given in Annex III of the Executable Test Suite as part of the annual LPIS Quality Assessment, was used for this comparison;

6. If present, the correspondent LPIS classes were selected and the degree of semantic match between the IPCC and LPIS was assessed;

7. The cardinality between the IPCC sub-categories and LPIS land cover classes was additionally calculated.

Cropland results

"Cropland management" is defined by the IPCC as a "system of practices on land on which agricultural crops are grown and on land temporarily set-aside from crop production".

There is a high degree of semantic correspondence between IACS and IPCC (see Table 3 and Table 4) and no major issue to address here.

Grassland results

The IPCC defines "grazing land management" as a "system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced." Generally, grazing land management occurs on land that has vegetation dominated by perennial grasses.

Here, "grazing" is actually used in a very broad sense, referring to "livestock production". It covers pastures used for grazing by livestock as well as meadows used for forage for livestock (green fodder, hay, silage).

The IPCC category of "grassland" includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and is not expected to exceed, without human intervention, the thresholds used in the forest land category. This category also includes

all grassland from wildlands to recreational areas as well as agricultural and silvo-pastoral systems, subdivided into managed and unmanaged, consistent with national definitions. For grassland in terms of accounting, IPCC defines this in terms of activities as "grazing land management".

Table 3 – Semantic correspondence between IPCC and IACS for cropland

IPCC sub-category	**Land cover classes in IACS / LPIS**	**Semantic match**
Annual crops	Arable land	YES (matching the given IPCC sub-category)
	Kitchen gardens	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
	Arable land with sparse trees	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
Perennial crops	Permanent shrub crop, permanent tree crop, permanent herbaceous crop	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
	Short rotation coppice	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
	Agro-forestry areas	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
Temporary fallow	Arable land (rain-fed with fallow system)	YES (Matching the given IPCC sub-category)

Table 4 – Semantic correspondence between IPCC and IACS for grassland

IPCC sub-category	Land cover classes in IACS / LPIS	Semantic match
Extensively managed rangelands and savannahs	Permanent natural grassland	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
	Permanent grassland (natural or managed)	PARTIAL (Can be attributed to more than one IPCC sub-category).
	Permanent natural grassland with shrubs and trees	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
	Permanent managed grassland[19]	PARTIAL (Can be attributed to more than one IPCC sub-category).
	Former agricultural land converted to wetland	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
Intensively managed continuous pasture	Permanent grassland (natural or managed)	PARTIAL (Can be attributed to more than one IPCC sub-category).
	Permanent managed grassland	YES (Specialisation of the IPCC sub-category). Should form part of the semantic aggregation.
Hay land	Permanent managed grassland	YES (matching the given IPCC sub-category)

Considering human-induced emissions or removals and precedence / hierarchy for accounting, in respect of article 3.4 of the Kyoto Protocol, decisions have to consider managed vs. non-managed land, e.g. seasonal grazing in semi-natural areas, such as heathland. Grazing land management also covers areas of wetland or forest where there is grassland in wetland areas, temporary grassland, grazing under forest.

[19] Regularly ploughed and reseeded grassland might be problematic, as in terms of SOC they are somewhere in between grassland and arable land. They cannot necessarily be distinctively identified in the LPIS.

Discussion

The semantic analysis revealed a very large degree of semantic correspondence between the IPCC land use categories and LPIS land cover classes at an aggregated level. The LPIS land cover class either completely matches the definition of the IPCC sub-category (1 to 1) or is its "specialisation" (resulting in one-to-many relationships). Since the "LPIS nomenclature" is of higher thematic detail, usually more than one LPIS class was assigned to a given IPCC sub-category.

A partial match was found in few isolated cases with respect to some IPCC sub-categories of managed (sown) and natural (self-sown) grasslands, since such sub-division is not always ensured in the LPIS. A similar partial match can be observed for some specific natural grassland types in less-favoured areas (LFA)[20] subject to extensive grazing – an issue that can probably be resolved with the use of ancillary data on LFA often recorded in LPIS). The interpretation of hay land as part of the IPCC category "grassland" needed more attention.

Hay can be produced from alfalfa and clover, occasionally even by cereals such as barley, oats and wheat (although more commonly in the form of straw). These are generally produced on arable land. We can however relate hay land explicitly to grassland, given the fact that in the IPCC definition the term "hay land" stands to indicate agricultural land specifically dedicated to the production of hay. However, when using LPIS data for national inventories, specific assessments and greater attention by each member state is warranted, for temporary and permanent grassland used as hay land, to allocate it to the right IPCC type of land use, should it be allocated to arable land in the specific member state's LPIS.

This apparent mismatch is solvable, considering that:

1. Although crops used for hay can be both graminoids and non-graminoids, they are all considered herbaceous plants from physiognomic (land cover) point of view. Thus, they fall into the category of herbaceous forage.

2. The production of hay might involve shallow ploughing in order to destruct sods, but the important element is that the reseeding is with some variety of herbaceous coverage. However, effects on soil carbon linked to the degree of tillage and the particular seed mixtures could be different. The possible need for ancillary data should therefore be assessed in each member state.

In general, by combining both criteria, it becomes evident that such herbaceous forage is present on the land for a long period of several years and falls within the current interpretation of the definition for permanent grassland by CAP. The DG AGRI guidance on Permanent Grassland (DS/EGDP/2015/02) also foresees the possibility of ploughing and reseeding permanent grassland, even with other varieties of herbaceous forages.

Therefore, in the majority of the cases hayland is related to land occupied by perennial grasses, which generally fall within the group of permanent intensive grassland that is subject to intensive farming.

Another apparent mismatch that needs consideration is the subdivision in IPCC of cropland into sub-types depending on the land use, which is necessary for the calculation of the annual carbon stock change. There are four sub-types of cropland in the IPCC LULUCF classification, to which we must refer:

- Long-term cultivated;
- Paddy rice;

[20] "Natural grassland" is not only found in LFA. Salt meadows and marshes along the Wadden Sea in parts of The Netherlands, Northern Germany and Denmark are natural grassland but the region is not (completely) part of a LFA.

- Perennial/tree crops;
- Set aside (for up to twenty years).

Although considered to represent the four major types of land use that can occur on cropland, all four sub-types have distinct bio-physical characteristics that reflect individual and separate land cover types. Except for paddy rice, the three other sub-types form part of the definition of cropland given in Section 3.3 of the IPCC guidance, that we already tackled by the semantic analysis. The sub-type paddy rice has a land cover class analogue (Rice fields – LCCcode 30001-S0308) in the LPIS of those EU Member States having rice cultivation, thus the semantic correspondence is ensured in this case, too.

Conclusion

The semantic analysis showed that all LPIS land cover classes within the IPCC scope fall in one, and only one, of the two major IPCC categories cropland and grassland. This gives good assurance that the extraction of IPCC land use data from the LPIS through semantic mapping and semantic/spatial aggregation can be relatively straightforward. However, for hayland, individual Member States should specifically assess and confirm this.

4.2.2. The management factor (F_{MG}) and input factor (F_{IN})

Management and input factor assessment methodology

Above, we proposed working definitions for management and input factors as "intensity of soil disturbance", "state of grassland degradation and improvement" and "material exchange of carbon in the form of crop residue and/or manure". As the input factor for grassland is essentially a specialisation of the grassland management factor, both input and management factors are analysed together.

The semantic analysis of the management and input factors requires:

1. An inventory and selection of the factors' categories that specify data needs;

2. Decomposition of the factors and the "real world" concepts that represent their core. At this point, there is no need to identify their qualifiers ("substantial", "normal") or parameters (>30%, "cotton") that are used as thresholds between the categories;

3. Identify, where appropriate, the corresponding IACS concepts and definitions. At the same time, trace the author / responsible for that definition;

4. Draw some conclusions of these findings for the subsequent search of data availability.

IPCC factor categories

The inevitable entry point of any analysis is the description of the factor categories.

The grassland input factor (medium / high) applies to improved grassland only, where no, respectively one or more, additional management inputs/improvements have been used (beyond that which is required to be classified as improved grassland). For this analysis, it is consider a mere quantifier for the grassland management factor.

Decomposition of IPCC data concepts,

The descriptions of the categories of Table 5 provide a series of "real world" phenomena as well as their qualifiers and parameters needed to classify data into one of the categories. As IACS/LPIS data represent a record of real world phenomena and activities, their semantic matching is a pre-requisite for any subsequent processing of IACS data towards IPCC data needs.

Cropland management refer to three levels of tillage. Correct allocation of these require knowledge of:

- (substantial) soil disturbance and/or full inversion.

Table 5 – IPCC concepts: Description of management and input factor (F_{MG})

IPCC categories		**IPCC Description**
Long-term cultivated cropland management	Full tillage	Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g., <30%) of the surface is covered by residues.
	Reduced tillage	Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30% coverage by residues at planting.
	No tillage	Direct seeding without primary tillage, with only minimal soil disturbance in the seeding zone. Herbicides are typically used for weed control.
Grazing and management	Nominal, non-degraded	Represents non-degraded and sustainably managed grassland, but without significant management improvements.
	Improved	Represents grassland which is sustainably managed with moderate grazing pressure and that receive at least one improvement (e.g., fertilisation, species improvement, irrigation).
	Moderately degraded	Represents overgrazed or moderately degraded grassland, with somewhat reduced productivity (relative to the native or nominally managed grassland) and receiving no management inputs.
	Severely degraded	Implies major long-term loss of productivity and vegetation cover, due to severe mechanical damage to the vegetation and/or severe soil erosion.
Long-term cultivated cropland input	Low	Low residue return occurs when there is due to removal of residues (via collection or burning), frequent bare fallowing, production of crops yielding low residues (e.g., vegetables, tobacco, cotton), no mineral fertilisation or N-fixing crops.
	Medium	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g., manure) is added. Also requires mineral fertilisation or N-fixing crop in rotation.
	High, without manure	Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied.
	High, with manure	Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure.

Within-year IPCC requirements for grazing land management refer to four states, depending on the observed:

- grassland improvement activities;
- sustainability of management;
- productivity levels;
- evidence of soil degradation and erosion.

The input factor for cropland management categories are based on the observed:

- practices of residue removal;
- annual crop (in combination with residue management) or rotation with bare fallow;
- (complementary) manuring;
- carbon input increasing practice (e.g., irrigation, cover crops or green manures, vegetated fallows, high residue yielding crops, and mixed crop/grass systems);
- fertiliser application (mineral fertiliser, N-fixing crops, organic amendments).

For each concept in the above inventory, we searched for a corresponding element in the IACS domain.

IACS concepts

Although essentially a common EU policy, the CAP regulations also adhere to the subsidiarity principle, as far as the dimensions of cross compliance, greening and rural development are concerned. As a result, defining "real world" phenomena that underlay the IPCC categories and finding the corresponding IACS concept cannot be derived from the regulations and rules alone. In practice, the analysis involves a fair amount of "expert judgement" in the field of these subsidiary instruments.

The result of this assessment is shown in Table 6. IPCC phenomena where no IACS correspondence is found are not included in the table.

Table 6 – Semantics of key concepts for the management factor (F_{MG})

IPCC concept	**IACS-GAEC correspondence**	**comment**
Tillage (soil disturbance)	Tillage as soil disturbance	Delegated to national definition
Soil disturbance with full inversion	Ploughing= tillage which destroys or alters the vegetation cover (land is turned over and/or the tillage is deep) ref. DS/EGDP/2015/02 rev. 4 art. 4.2	IACS definition - mandatory ban for ESPG
Residue	Residue = part of crops remaining on the land after harvesting of the crop grown thereon such as straw, stubble or parts of any crops	Delegated to national definition - optional for specific territories and seasons

IPCC concept	IACS-GAEC correspondence	comment
Bare fallow	Field maintained as bare of crops or weeds	Delegated to national definition - optional ban in specific territories
N fixing crops	Nitrogen-fixing crops that contribute to the objective of improving biodiversity and which are present during the growing season. MSs define lists of nitrogen fixing crops, rules on where they may be grown (taking into account objectives of directive 91/676/EEC and 2000/60/EC) and additional conditons with regard to production methods (Reg. 639/2014, art. 45 on EFA)	IACS definition – applicable to a subset of all possible N-fixings crops
Manure	Organic matter used as fertiliser derived by animal excrement: liquid manure = manure mixed with water livestock manure = from livestock poultry manure = from poultry	Common definition derived from the Nitrate Directive
Green manure	Green manure = crops grown for the purpose of ploughing them into the soil	IACS definition
Cover crop	Cover crop: any crop grown to provide soil cover, regardless of the period (annual, biennial or perennial) and the duration (all or part of the year). A cover crop could be any temporary vegetative cover between successive agricultural crops, or between rows of trees.	IACS definition
Improved vegetated fallow	Fallow covered by vegetation. The concept of "improved" is not present.	No correspondence
Overgrazing	Overgrazing: exposure of plants to intensive grazing for prolonged periods of time or without sufficiently recovery period. In some cases (e.g. in Scotland) land is considered to be overgrazed provided it is not capable of recovering anytime	IACS definition

IPCC concept	IACS-GAEC correspondence	comment
	during the growing season in the following calendar year.	
Degraded grassland	The practices, other than overgrazing, linked to grassland degradation are poaching by animal and excessive rutting by machinery	Delegated to national definition
Sustainably-managed grassland	In Natura 2000 areas, provisions in Article 6 of Directive 92/43/EEC, detailed conservation measures (which are often indicated in management plan rules) set up by the Member States and criteria to avoid the deterioration of habitats and disturbance of species (detailed management plans put in place by competent Natura 2000 authorities).	Common definition derived from the Nature2000 framework. In Natura2000, sustainability is more oriented towards biodiversity than climate mitigation[21].

Discussion

Table 6 identifies several types of correspondence possibilities. The most straightforward case is where an explicit IACS definition is found. As IPCC did itself not explicitly define any of these concepts, this can be considered as a 100% semantic match.

Equally convenient are the cases where a common definition is present, even if such definition is not laid down in the IACS regulations, but inherited by the common environmental legislation, although there remains a need for some caution.

Where the practical definition is delegated to the national authorities, a case-by-case analysis will be needed of what the national transposition means in terms of IPCC concepts. This will be done shoulder to shoulder with the analysis of the data availability.

Finally, IPCC real-world phenomena that are not included in Table 6 relate to concepts that can now be conventionally elaborated by the IACS community as they are not fixed by the CAP, nor by environmental or national definitions:

- frequency of tillage operations;
- abundance of residues at time of planting.

[21] Lowland and mountain pastures, albeit part of the habitats directive, might also be regularly fertilised and often drained.

This analysis did not discover any terminology mismatch, i.e., the IPCC methodology does not assign a different meaning to any term that is also present in the IACS domain[22].

Conclusion

Management and input factor categories cannot be directly derived from IACS/LPIS data but many, if not most, real world phenomena reflected in the IPCC methodology correspond to the common CAP or environmental legal definitions. Some phenomena have not yet been defined in the IACS domain but no terminology mismatch is found.

For the definitions that are essentially delegated to national authorities, their existing norms and rules regulating Good Agricultural and Environmental Condition (GAEC) need to analysed case by case, but if correspondence is found, that definition can be applied to all parcels in that territory. This will be done in the data availability chapter below.

4.3 Data availability

4.3.1. The land-use factor (F_{LU})

Assessment methodology

In the previous section, we assessed the semantics of IPCC and IACS, and established that IPCC land use categories match with LPIS land cover aggregates. In this chapter, we assess whether the information required by IPCC is correctly represented/recorded in LPIS.

It is important to check if there are instances where this information is still incomplete in the LPIS systems of the EU MS. In order to assess the potential availability of land cover information related to IPCC in the LPIS systems of the EU Member States, the following approach has been implemented:

1. For each LPIS implementation, the so-called "eligibility profile" is assessed. The eligibility profile holds the list of agricultural land cover types as defined by the given MS administration for the annual LPIS quality assessment and should in principle reflect the thematic content stored in the LPIS data model.

2. Findings are compiled in a table where an indication is given for each EU MS whether the LPIS stores information on the different agricultural land cover types within the reference parcel, and whether a subdivision between managed and natural grassland is made.

There is no absolute certainty to what extent the eligibility profiles (EP) correctly reflect the information actually stored in the LPIS. In fact, EPs were introduced as the legend in the annual LPIS quality assessment to express land cover polygons delineated during inspection in terms of IACS eligibility. Certain EU MS might apply the detailed land cover classes from the EP only to the sample of reference parcels subject to the LPIS Quality Assessment (where this subdivision is compulsory) and delineate RP in their LPIS in a single agricultural land category only. In addition, even if we are confident that the distinction between the different agricultural land cover types is inherent in the given LPIS design, we still cannot be a priori sure whether the relevant spatial or alphanumeric information is correctly recorded in the LPIS.

Results

The results of the EP analysis are compiled in the graph in Figure 2.

[22] The possible exception of some grassland or hay land would have to be assessed on the level of each member state.

The inventory of the eligibility profiles from the 2011 LPIS Quality Assessment showed that it is very likely that all EU Member States have been keeping the information of the different agricultural land cover types in their LPIS, in one form or the other, at least for the last few years. Additionally, well over a third of them have the potential to discriminate between managed and natural grassland. The same proportion of MS has defined specific natural grasslands (usually subject to extensive farming). This is a potentially important contribution to estimating the factor for the management practices.

Because IPCC allows the use of statistical samples, a number of parcel that are consistently and regularly followed over the years could be monitored. There is thus no limitation to the usefulness of IACS / LPIS for LULUCF reporting.

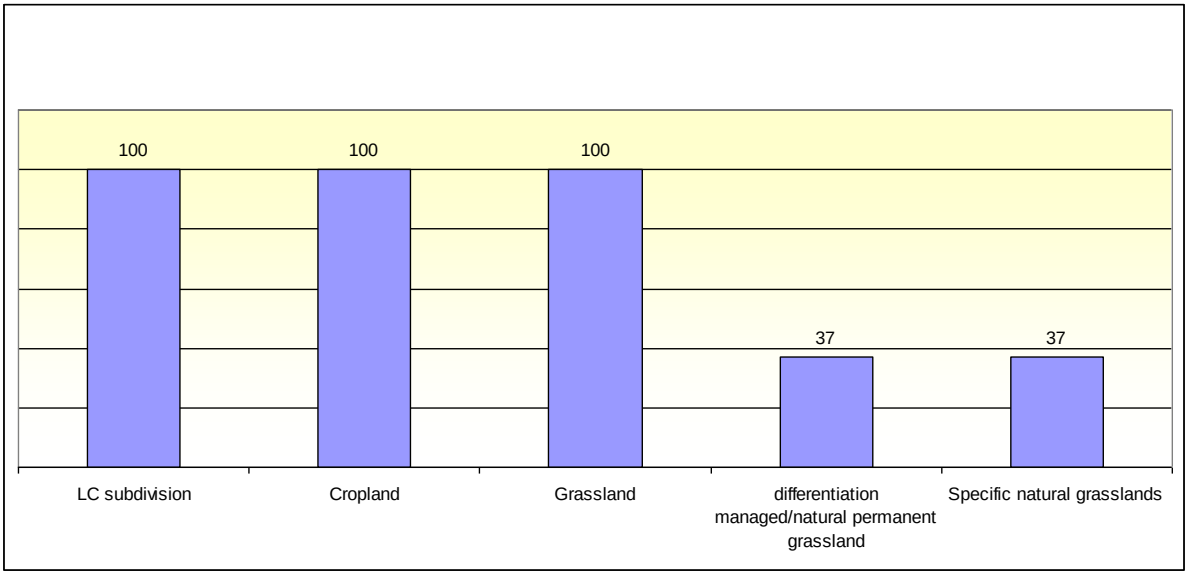

Figure 2 – Percentage of LPIS custodians declaring to have the identified land cover types in their eligibility profiles (from 2011 onwards)

The next obvious key question is whether this land cover data is stored spatially (separate land cover layer), or is only available alphanumerically at the level of the reference parcel. The mode of storing land cover data in LPIS impacts the approach for extraction of IPCC land use data from the LPIS through semantic mapping and semantic/spatial aggregation to larger and stable spatial units.

With the current state of reporting, it is impossible to provide a final status for each of the 44 LPIS systems in Europe (although the necessary instruments in the LPIS QA to check for this information will be available from 2016). It is however possible to identify various scenarios.

Table 7 outlines the different scenarios possible, depending on the degree of semantic matching, data availability and recording mode in the LPIS.

Table 7 – Scenarios for extracting IPCC-related land cover/land use data from IACS/LPIS

Semantic match between IPCC categories and LPIS classes	**LPIS Data availability**	**Mode of land cover data storage**	**Aggregation and generalisation method – issues, bottlenecks**
Complete	Fully available	Graphical (spatial)	No specific issues, except for the computation complexity in case of vector-based approach. Semantic mapping and spatial aggregation with the highest level of confidence.
	Fully available	Attribute (alphanumerical)	Possible use of raster (grid-based) method for aggregation.
Partial	Fully available	Graphical (spatial)	Gap analysis required. Problematic cases are evaluated. External thematic datasets and class matching methods are consulted.
	Fully available	Attribute (alphanumerical)	Sematic gap analysis is required. Problematic cases are evaluated. External thematic datasets and class matching methods are consulted. Possible use of raster (grid-based) method for aggregation.
Complete	Partially available	Graphical (spatial)	Spatial data gap analysis is required. Problematic cases are evaluated. External datasets are consulted to complement the missing data.
	Partially available	Attribute (alphanumerical)	Spatial data gap analysis is required. Problematic cases are evaluated. External datasets are consulted to complement the missing data. Possible use of raster (grid-based) method for aggregation.
Partial	Partially available	Graphical (spatial)	Semantic and spatial data gap analysis is required. Problematic cases are evaluated. External datasets are consulted to complement the missing data. External class matching methods are consulted.
	Partially available	Attribute (alphanumerical)	Semantic and spatial data gap analysis is required. Problematic cases are evaluated. External datasets are consulted to complement the missing data. External class matching methods are consulted. Possible use of raster (grid-based) method for aggregation.

4.3.2 Assessing the correspondence between IPCC requirements and GAEC-rules

Assessment methodology

As highlighted above, data requirements for management and input factors depend firstly on the semantic correspondence. In contrast to the land use factor, whose definition and availability is essentially common for all systems, for input and management, implementation and availability must be approached from the context of the GAEC rules under subsidiarity.

We have therefore analysed all existing GAEC rules and searched for correspondence. This also required a fair amount of expert judgement and an equally subjective interpretation.

Findings and discussion

Three GAEC requirements are relevant for LULUCF. These are

- GAEC 4, "Minimum soil cover",
- GAEC 5, "Minimum land management reflecting site-specific conditions to limit erosion", and
- GAEC 6, "Maintenance of soil organic matter level through appropriate practices including ban on burning arable stubble".

Within the overarching EU framework, each Member State defines the specific requirements that can potentially provide items displaying common semantics with IPCC. The results are summarised in Table 8.

These analyses show that there can be in some limited cases an incomplete match between GAEC and IPCC requirements. Member States decide autonomously on specific rules for GAEC, based on the general EU framework but adapting the specific norms to the specific national or in some cases even regional characteristics. Even in MS where a specific rule has some bearing on addressing IPCC requirements, the match is in most cases quite limited. Although the corresponding data is not georeferenced, it is assumed that all land characterised by certain specific elements (e.g., crop type, slope, and other characteristics) must respect the applicable conditions.

Table 8 shows some potential sematic matches. Table 9 provides further details on the analysis, showing the potential use of some GAEC requirements, in some MS, for LULUCF reporting and accounting. Semantic matching and data availability are partial at best.

As an example, for BE-FL, GAEC 5 says that in some specific cases a number of measures become compulsory. These measures include, e.g., conservation tillage. Two major aspects of this should be noted. These measures are only compulsory for land "parcels with a very high risk of erosion". The concept of "very high risk of erosion" is not (or not always) better defined in the GAEC notification, albeit in some other MS it may be (e.g., specifying parcels with a slope above a certain threshold). In BE-FL, the requirement applies to "winter cereals, winter rape, spring cereals, flax and spinach" More importantly, in order to be cross-compliant, the farmer can "[either] sow in the direction that best follows the contour lines if the parcel is longer than 100 metres in that direction or apply conservation tillage".

In this case, thus, if a farmer applies the first part of the rule (i.e., if the farmer sows in the direction of contour lines) and does not apply conservation tillage, that farmer is considered to be respecting cross-compliance. There may currently not be an indication in the database on which of the two options that specific farmer has complied with on specific parcels of land.

Similarly for EE, "minimised soil preparation" is only one of several possible practices to comply with these requirements. Farmers can also meet compliance requirements in other

ways, "such as cultivation of land across the slope" in which case there would be tillage anyway, generally leaving less than 30% residues at the time of planting.

As another example, for DK and ES, while one can summarise the GAEC rule as (including) "no reversal tillage", it is similarly problematic to consider this as a clear match. In this instance, in fact, the GAEC standard prescribes to limit tillage in terms of when it can be done and how. Rules ban tillage in a certain period of the year[23] and under certain conditions of slope, and not in the direction of the slope. However, this may still fall in most or even all cases under what the IPCC calls "Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g., <30%) of the surface is covered by residues." For example, in DK as from 16 February, farmers can actually plough, therefore at the time of planting there would be in any case no or very little residues left.

GAEC data currently poses challenges for addressing the needs of LULUCF GHG accounting. However, there is great potential for developing towards the collection of information on the IPCC practices. Some of the rules provide an instrument for targeted action in the near future. In fact, there is a fair amount of theoretical semantic correspondence and MS could assess the interest of sensibly adapting the rules so they are more in line with LULUCF accounting requirements, within the time frame of Decision 529/2013. This can be realistically achieved, while respecting the current aim and role of the GAEC-related rules.

4.3.3 Discussion on data availability

The option to access immediate off-the-shelf data availability from IACS/LPIS for the purposes of LULUCF accounting has been dismissed. However, a robust common EU framework exists, that would enable Member States to use the existing infrastructure and processes.

There are also varying ways that the member states have used to set up their systems.

IACS/LPIS offers a robust, well-managed and quality assured geographical information system (GIS), based on the current differentiation between cropland and grassland (the LU and area factors). The LPIS reliably functions as the backbone for the annual declaration of land use. That land use declaration comes with mandatory and optional information on practices that correspond to the elements of the IPCC input and management factors.

The major selling point of any GIS, hence also of the LPIS, is that its spatial canvas enables the integration and processing of data from any other source, on condition that those other data have an implicit or explicit spatial component. Furthermore, the above analyses on semantic correspondence and data availability revealed that there are no particular constraints or obstacles to plug LULUCF information into the IACS/LPIS system.

The resulting plugin will depend on one of more of the following extensions

- Alignment with other pan-European inventories and data sources. to extract and integrate missing data in LPIS;
- To derive the area factor from the LPIS/IACS historical records and update cycles;
- To retrieve missing information through the (geospatial) aid application in a crowd-sourcing capacity (so it is neither based on CAP-compliance nor subject to its before-payment control processes).

[23] For example, for DK, "from harvest to 15 February in the following year".

Table 8 – Semantic analysis of GAEC data / concepts that can match requirements for IPCC factors

IPCC Factor	Factor's Level	GAEC requirements	Scope of GAEC application			Semantic analysis (match)
			Time	Land	Land use	
Management factor (F_{MG})	Full tillage	*None*				
	Reduced tillage	Conservation tillage (BE-FL)			Cereals, winter rape, flax and spinach.	Low
		No reversal tillage (DK, ES)	From harvest to late winter	Slope > 12 degrees; areas at risk of erosion		Low
		Minimised soil preparation (EE)		Slope > 10%		Low
		Strip cropping, minimum tillage or conservation tillage; conservation-tillage techniques (defined by Regions) (ES)				Low
	No tillage	*None*				
Input factor (F_I)	Low	*None*				
	medium	Incorporate green manure crop on arable land (NL)			After maize and cereals	Low
		Incorporate green manure if burning stubble (IT, MT)				Low
	high without manure	*None*				
	high with manure	Incorporate solid manure or solid organic manure (CZ)			On 20% of arable land	Low

IPCC Factor	Factor's Level	GAEC requirements	Scope of GAEC application			Semantic analysis (match)
			Time	Land	Land use	
Management factor (F_{MG})	Nominally managed (non-degraded)	Avoid overgrazing, poaching by animal and excessive rutting by machinery (UK, IE)				Medium
	Moderately degraded grassland	*None*				
	Severely degraded	*None*				
	Improved grassland	*None*				
Input factor (Fi)	Medium	*None*				
	High	*None*				

Table 9 – Results of analyses of GAEC requirements and the availability of data for IPCC requirements

IPCC LULUCF	**Factors**	GAEC	**IACS - Good Agricultural and Environmental Condition (GAEC)**		
			Requirement	**Frequency**	**Comment**
CROPLAND MANAGEMENT	Management factor (F_{MG}) *Tillage*	GAEC 4 - Minimum soil cover	Tillage requirements (such as minimum tillage) as an alternative to cover crop	Low (2 MS)	Implementation at farm level (to be verified case by case)
		GAEC 5 - Minimum land management reflecting site-specific conditions to limit erosion	Conservation tillage related to specific erosion-prone land	Medium (11 MS)	Geographical implementation (based on territory and/or parcel)
	Input factor (F_I)	GAEC 4 - Minimum soil cover	Leave crop residues on the ground Sow a green manure cover	Low (5 MS)	Geographical implementation (based on territory and/or parcel) Implementation at farm level
		GAEC 6 - Maintenance of soil organic matter level through appropriate practices including ban on burning arable stubble	Crop residues shall nor be burnt Incorporation of crop residues into the soil	No burning: high (all MS) Incorporation: low (3 MS)	Generalised implementation Implementation at farm level (for incorporation into the soil)
GRAZING LAND MANAGEMENT	Management factor (F_{MG})	GAEC 5 - Minimum land management reflecting site-specific conditions to limit erosion	Avoid overgrazing Avoid mechanical damage (rutting) Avoid poaching	Low (4 MS)	Generalised implementation
	Input factor (F_I)	None			

An additional selling argument for IACS is that with its common origins, it comes with a broad community and a large competence base and any of the required developments and experiences would be shared by all Member States.

4.4. Member States' concerns

4.4.1 General aspects

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Representatives of the IACS/LPIS community of five member states (Denmark, Germany, Italy, Romania and Slovenia) contributed to initial assessments of constraints and helped to analyse potential concerns. A key expert meeting and additional direct contacts provided us with the following main points to address.

On general aspects:

- IACS/LPIS communities are generally not thoroughly knowledgeable of detailed IPCC methodologies and of the LULUCF requirements in terms of reporting and accounting. They express specific needs for contacts with the administrations responsible for IPCC reporting and accounting, although in some cases these contacts were at least partly established.
- IACS/LPIS communities expressed a major need of clarification concerning the semantics, in particular concerning permanent grassland and its meaning for IPCC and for IACS/LPIS;

On aspects related to data availability and to the type of data:

- Some additional / more precise data could become available through an extension of the geospatial aid application (GSAA) that is due to become mandatory starting with the campaign year 2017. Several member states are already operating a GSAA while most have already begun to implement. Additional LULUCF information might be delivered through the GSAA, and Member States could focus on the farmer as provider of data. It appeared as a fundamental necessity that this is harmonised on the EU level and preferably established in EU Regulations, rather than left as a burden for each individual member state;
- Issues of data privacy need to be addressed and data retrieval and processing should be defined in detail and agreed between Ministries, paying agencies and the administrations in charge of IPCC reporting and accounting;
- In most cases the IACS/LPIS custodian is not the same administration as the one responsible for IPCC reporting and accounting; This must be addressed, especially in member states with a federal or regional institutional setting;
- Long term time-series data could be a challenge under particular member-state legislations; in one example, LPIS data must be deleted after the Regulatory archive period of ten years[24].

4.4.2 An illustration: Germany

To illustrate the last three points in a specific example, we discuss the case of Germany.

[24] In the case of Germany, e.g., the Data-Protection Law of 2 December 2014 (BGBI.I S. 1928.1931), amended by Article 4 of the regulation of 24 February 2015 (BGBI. I S. 166), also deals with processing and utilisation of data within the framework of the integrated administration and control system. Section 7 of the law stipulates the deletion deadlines of these data must be at the latest ten years after the year of data acquisition.

Article 117 of Regulation 1306/2013 (EU) deals with the processing and protection of personal data in the framework of IACS. Personal data can be collected for the purpose of carrying out management, control, audit, as well as monitoring and evaluation obligations under this Regulation. They can also be collected for statistical purposes. The administrations shall not process this data in a way that is incompatible with such purpose.

Pursuant to this article, when personal data are processed for monitoring and evaluation purposes, as well as for statistical purposes, they shall be made anonymous and processed in aggregated form only.

In Germany, the Federal Ministry of Justice and the Federal Data Protection Commissioner interpret this article in such a way that data can only be used for the purpose defined in the Regulation. This implies that neither the federal government nor the regions may use the data for CAP monitoring and evaluation nor for IPCC reporting and accounting

Non-aggregated personal data may not be used as input for processing by third parties outside the organisations legally designated for the management of IACS data (i.e., the paying agencies). That means that statistical offices may not use non aggregated personal data to, e.g., enrich the data of the farm structure survey.

Personal data are all those containing specific information of a single natural or legal person. With regard to GIS data, there is an ongoing and yet unsolved debate whether high-resolution data on the parcel level (as required for fine-gridded data processing for LULUCF reporting) are personal data.

Combination of IACS data with data in the system for the identification and registration of animals offers opportunities to understand better manure application on land and their impacts on soil organic matter. However, the joint use of IACS and animal register data for IPCC reporting and accounting involves problems of data purpose and data confidentiality.

Because of the legal framework conditions, German IACS data currently can only be used for explorative scientific or evaluation studies on behalf of the federal states (Laender). For IPCC reporting and accounting, a responsibility of the federal central government, there is no data access.

Similar data access issues could be found in other member states. One could argue that these issues can be overcome in order to achieve results and to meet the KP accounting obligation in the most efficient and cost-effective manner. If anything, it is clear that these issues need to be addressed.

4.5.2 Other studies on the use of LPIS for LULUCF

A report by Weiss et al (2015) has addressed the use of LPIS for LULUCF accounting by EU member states. It reported that as of 2014, only eight member states (or region / countries for Belgium and the UK) used LPIS data for LULUCF, and most of them only partially. The report's authors also carried out a questionnaire survey of member states to address their use of LPIS and gather feedback on potential and issues.

Twenty-three member states (or countries or regions) that reported they were not using LPIS gave various reasons. Five had no knowledge of LPIS, or had not yet explored it, or had no contact with the responsible service. Two stated that LPIS will be used in future UNFCCC / KP reporting submissions, and one declared it was not using it because it demanded time-consuming, intensive data analyses.

The other fifteen gave the following reasons:

- Data are not complete and/or consistent with other sources;
- Data are not publicly accessible;
- Data not sufficient & readily practicable; not applicable;

- Data are not consistent over time.

The report clearly confirm that completeness of the dataset covering all land is not a requirement for IPCC methodologies. Statistical approaches are regularly used, and accepted, for reporting under the UNFCCC and its KP. This is the case in forest inventories. Data must be representative. Austria reportedly uses such an approach, reducing the number of LPIS parcels to a representative subset to then track continuously over time.

Weiss et al argue that data access should be overcome, considering GHG reporting is often done at a very aggregated level. Data is made available for analysis without sensitive personal data.

There can be an issue with detailed georeferenced data at the parcel level to apply approach 3 and tier 3 methods, but workarounds are possible. These include designing a semi-automated routine. Member states' administration staff already authorised to treat this personal data could perform the initial semi-automated analysis as the first step to IACS/LPIS data use. They would thus obtain an aggregated land-use change matrix, based on geo-referenced information. The subsequent steps for further elaboration would then use such a matrix at an already aggregated and anonymised format. Once the routine correctly designed, these steps could run in the background on the servers that already store the detailed and protected LPIS data for other purposes.

Weiss et al (cit.) convincingly point out that, although data may indeed in some cases be insufficient or its use not readily practicable, it may be better to make adjustments to the national IACS / LPIS system rather than introducing, developing and maintaining a separate system for GHG reporting and accounting.

Where it is claimed that data might be inconsistent over time, the authors of the cited report highlights that one solution may be to analyse only a smaller, representative but consistent subset of land parcels. Austria, for instance, reduced the dataset to approximately one third of the total farmed area, thus covering still a larger share of the total as opposed to the approved and established use of forest inventories.

4.5 Methods to complement IACS-data for LULUCF accounting

It is not within the scope of this study to list and elaborate on all possible methodologies that are required to make the plug-in on IACS/LPIS work for LULUCF purposes. It suffices to provide some elaborate examples that represent "proof of concept" for the feasibility of similar methodologies.

What will be required for an individual IACS/LPIS/MS will depend on the data already available in that system.

4.5.1 Interacting with CORINE Land Cover

Assessing the thematic scope

In principle, one can expect the LPIS to hold the spatial information of all agricultural land available in the country. This is not always the case, since some LPIS designs have relied on the agricultural area that is declared by farmers. Furthermore, as the LPIS scope covers land that can be declared by farmers for CAP support schemes, it can omit portions of utilised agricultural area or certain parts that are too small to meet a certain minimum size. This minimum size could be smaller than 0.3 ha.

The reformed CAP (post-2013) extends the previous definition of permanent grassland, which allowed only area covered with perennial herbaceous vegetation (not subject to crop rotation for 5 years or more) to be considered as grassland. Pursuant to article 4.1(h) of Regulation 1307/2013, grassland may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant. Member states might decide to consider as eligible for the basic payment scheme (BPS) grazing areas where grasses and other herbaceous forage are traditionally not predominant, providing that such land can be grazed and that such grazing is part of

established local practices. Those areas are called "permanent grassland under established local practices (PG-ELP)".

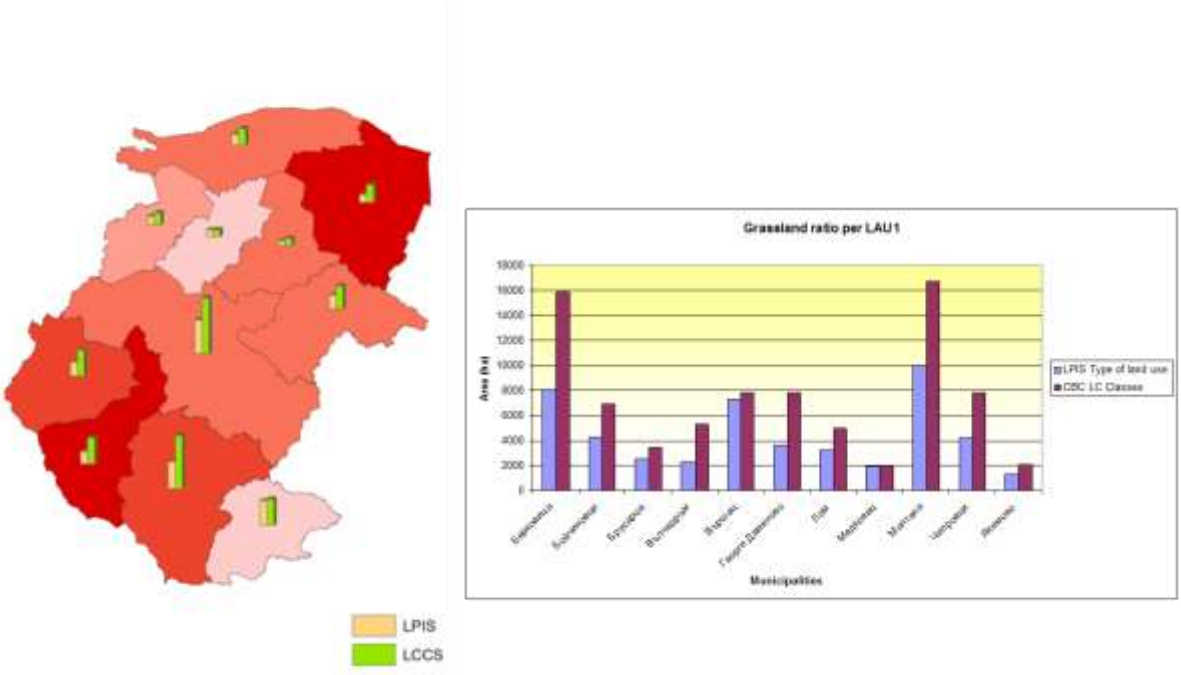

Figure 3 - Abundance of permanent grassland (ha) in the LPIS and in the reference CORINE land cover (LCCS=base) for a NUTS-3 region in Bulgaria (2013 data, CBC project "SPATIAL", ASDE)[25]

The extension of the definition of permanent grassland means that new areas that were previously not eligible for agriculture support, have now become so. This called for a revision and update of the spatial and thematic extent of the affected LPIS. New land cover types and areas need to be accounted and mapped in the system. Member States are already in the process of updating and upgrading of their LPIS systems in order to meet these new requirements. To do so, they rely on farmer inputs, orthoimagery, third-party data and inputs from their inspectors. However, the extent of land affected and the complexity of this inventory vary from country to country, thus the level of LPIS completeness with respect to these new grassland types is at present relatively dissimilar. One can expect the situation to normalise in a relatively short time after the immediate post-reform adjustment period is over.

Assessing the area factor

A rough-to-relatively-accurate estimate of land not accounted for in the LPIS can be made once the LPIS is confronted with external dataset of comparable thematic accuracy and cartographic scale at least matching the pan-European products used by EC for statistical purposes such as CORINE Land Cover.

A recent study jointly conducted by Bulgaria and Romania over their cross-border area provided estimates at the level of the local administrative units (LAU1) on the rate of permanent grassland potentially omitted by the LPIS by comparing the LPIS data with cross-border reference land cover data at a scale of 1:25,000. The LPIS data were the year 2013, prior to the introduction of the new CAP.

[25] The different shades of red in Figure 3 show the difference in the area from both datasets.

A similar study can be conducted on a pan-European level, based on the centroid points of all reference parcels holding eligible land, together with the up-to-date maximum eligible area as reported in their LPIS. This data is annually provided to the JRC for the purpose of the LPIS Quality Assessment. Two types of spatial analysis allow comparing the LPIS data with external pan-European datasets.

- Using the centroid points themselves
- Using a raster mask of the potential area footprint of the centroid points

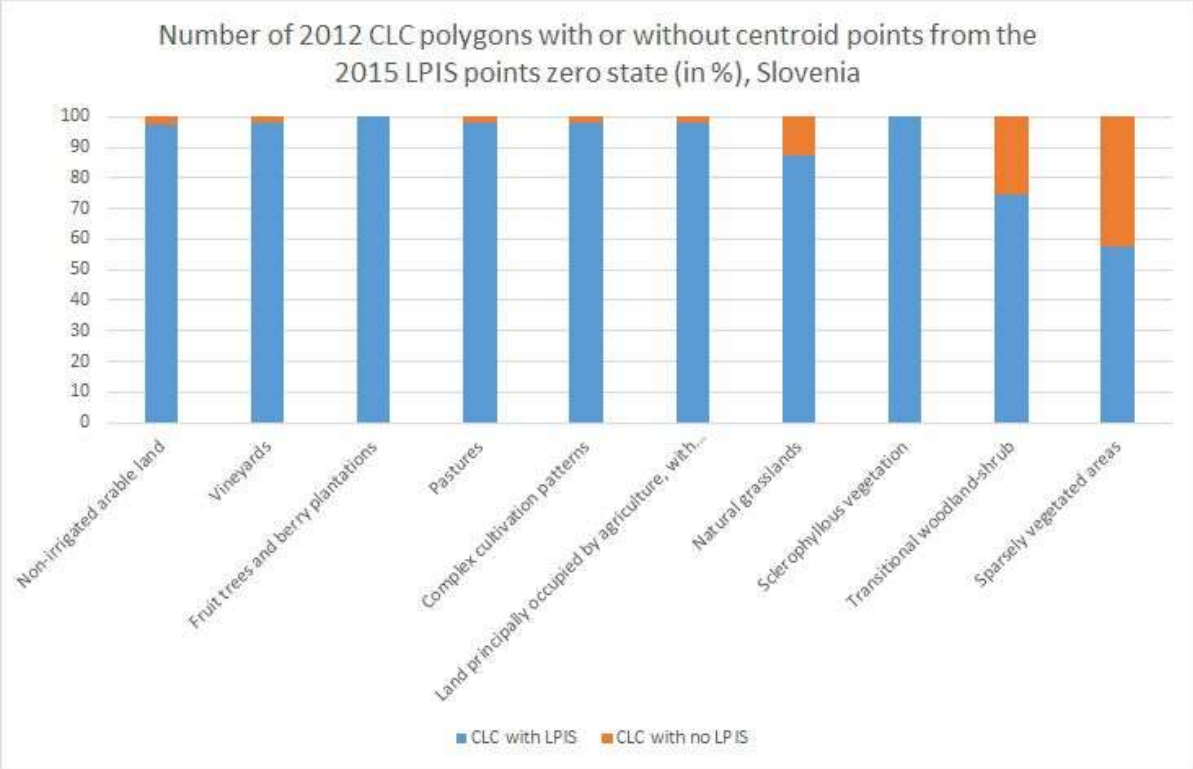

Figure 4 - Number of CLC polygon in the "agriculture" land cover class with or without LPIS centroid point

The spatial analysis using the centroid points is relatively easy, as is relies on well-know and established spatial operators embedded in almost all standard GIS platforms.

The drawback is that comparing points against polygons would work appropriately only if the polygons features of the external dataset are of the same or comparable level of detail and cartographic scale, as the reference parcels represented by centroid points. The difference in the spatial (and to a certain point also thematic) resolution between the datasets should not be of such a magnitude that they become incomparable.

As an example, results of preliminary analyses for Slovenia are provided in Figure 4 and Figure 5.

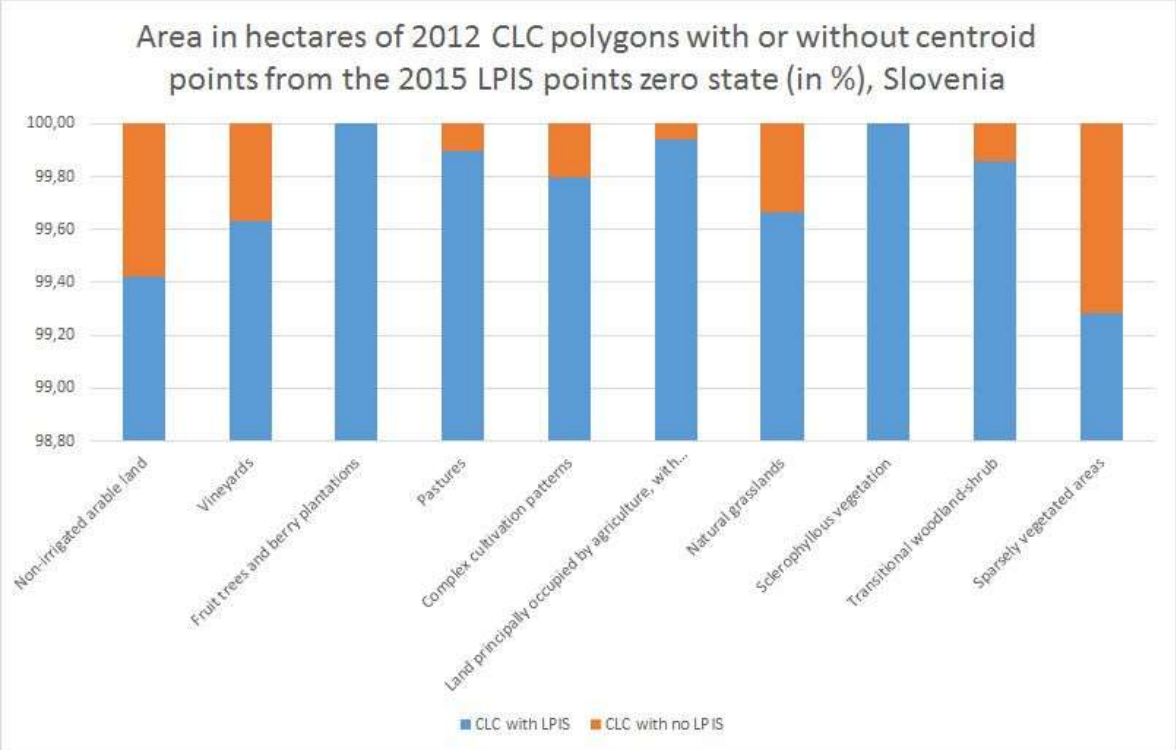

Figure 5 – Area in hectares of CLC polygon of the "agriculture" land cover class with or without LPIS centroid point

Searching for missing agricultural land

The other approach uses a raster mask (under development by the JRC MARS Unit). Although more complex, it might give more meaningful results, as it tries to account the potential area footprint of the centroid points of the reference parcels and its spatial extent. This type of analysis based on vector data would be very time- and resource-consuming if conducted on a pan-European level. In fact, the approach requires both the LPIS and external datasets to be converted to raster. The resulting raster dataset for LPIS represents the share of the LPIS eligible area with each raster cell of 100x100 meters. Results of such analysis (for Malta) are given in Figure 5.

By no means can such analysis be used as an assessment of the accuracy of the LPIS itself, since in almost all cases the external reference dataset will be of inferior spatial resolution and accuracy compared to the target 1:5,000 scale of the LPIS. However, it can be used as an indication of whether the LPIS holds correct information on cropland and grazing land as needed for LULUCF accounting requirements.

Certainly, prior to any such comparison, the semantic correspondence between the land cover definitions used in the different products needs to be evaluated. Such assessment can comprise three major steps:

1. A decomposition of the class definitions used in the external dataset with the Land Cover Meta Language (ISO 19144-2 - LMCL) and their modelling with the TEGON approach of GTCAP
2. Comparison of the resulted definition with correspondent classes in LPIS, expressed in LCML terms according to Annex III of the LPIS Quality Assessment Framework
3. Assessment of the compatibility and cardinality for each of the class pairs.

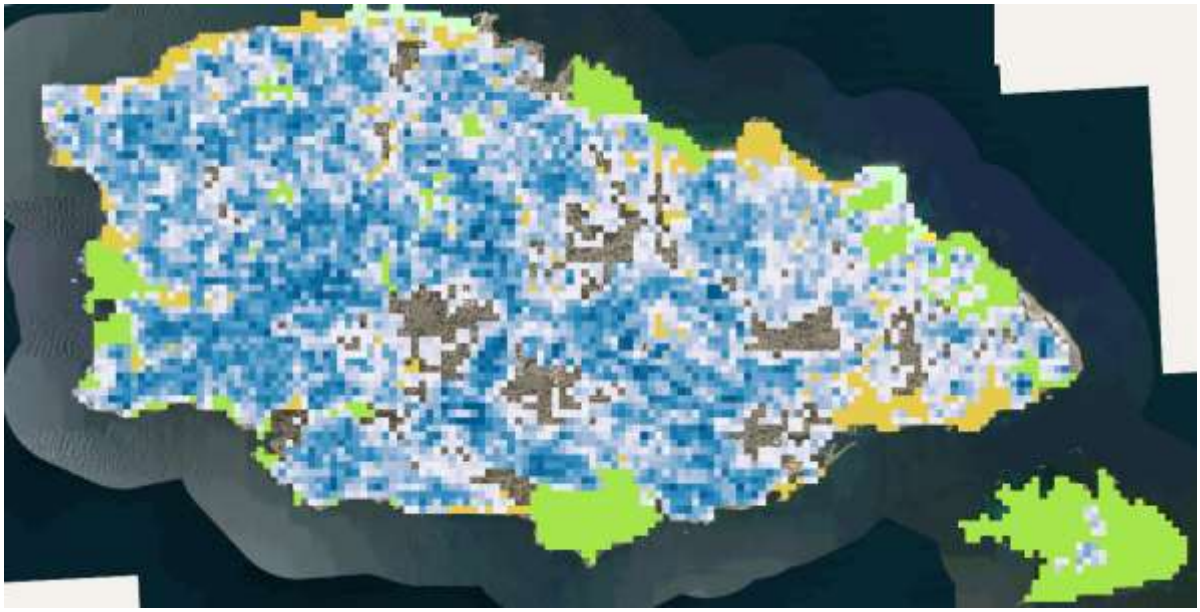

Figure 6 – Mask of the area footprint of the LPIS centroid (in blue shades) overlaid on top of CLC raster data (Island of Gozo, Malta).[26]

4.5.3 The (geospatial) aid application for input and management information

Much of the information on input and management is available at the very source: the farmer. From an environmental stakeholder's viewpoint, that farmer is a distant actor and the information is beyond the horizon. Not so from the direct payment actor's perspective: the farmer is an active party who, in return for his income support, manages the land and also provides public services to preserve biodiversity and help climate mitigation.

There is therefore a direct legislative link between the farmer's application for EU aid and the MS's accountability for the LULUCF sector. However, that information provided by the farmer can or should not be subject to eligibility for aid or the corresponding controls.

The information should rather be approached as if it were a separate annual census, preferably with an independent quality control mechanism.

The advantage of this approach is that it plugs in on existing and well-managed systems. There is little need to redesign databases or overhaul the current application process. All that would be needed is a simple user-friendly, extension of the CAP aid application form to collect the parameters and qualifiers of the IPCC management and input factors, which as the semantic analysis reveals, mostly depends on the already mandatory declaration of the crop. Intelligent design of the application form could reduce administrative burden for the farmer to a very minimum. With the geospatial application, processing by the administration would be virtually completely automatic.

Since such additional information, although provided by the farmer concurrent with its aid declaration, relates only to real world practices and have no direct connection to the applicant, data privacy conditions should not be a concern. Alternatively, when designing the system, the necessary precautions can be taken in order to ensure that data collection

[26] The green and yellow pixels in Figure 6 are areas classified as agriculture in CLC 2012, but not accounted as such in the LPIS.

is not subject to privacy restrictions, in the sense that as a minimum and explicitly declared effect, data collected can be shared by the CAP paying agency with the LULUCF reporting authority.

4.6.5 Third party data retrieval and use

Methodologies and related costs for third party data retrieval will depend on the conditions and accessibility of those third-party data.

For EU-wide data, LUCAS, FADN, Corine Land Cover, shared methodologies will obviously greatly improve their use and reduce the corresponding costs. Below are two examples of candidate methodologies to be shared by all systems.

The recently finalised project "Assistance to the EEA in the production of the new CORINE Land Cover (CLC) inventory, including the support to the harmonisation of national monitoring for integration at pan-European level" made a very useful analysis of the possible generalisation and aggregation methods of vector or raster data, which allows for the derivation of coarser resolution European data sets from higher resolution national data sets (following the concept of bottom-up approach). The resulted report also provides a collection of best practices, as well as a methodology for identification of problems and proposed solutions. See also:

http://land.copernicus.eu/eagle/files/documents-and-reports/t32-cigar/view

Another relevant deliverable for the same project is the development and assessment of the so-called grid approach. The report assess the advantages and disadvantages of the "grid approach" , with the aim to find out how feasible it is to store land cover information in a regular grid, taking into account different levels of details. An important aspect that was considered is the connection to statistical analysis and time lines". The report can be found on:

http://land.copernicus.eu/eagle/files/documents-and-reports/t42-grid-approach

4.6. Cost analysis

With the diversity of LPIS design options, GAEC rules, the resulting data availability and state of the geospatial application, a meaningful cost analysis can only be made per individual cost component. Each LPIS implementation has to evaluate which changes it individually has to implement. In this report, we merely list the various operation and provide a range of costs for each.

4.6.1 Designing the database upgrade

Ensuring interoperability of the IACS database content (or processes) with the LULUCF data needs requires an adaptation of the conceptual design. The steps are very similar to those explained in this report.

1. Analyse the semantic correspondence as in chapters 4.2 and 4.3
2. Identify the LULUCF concepts, qualifiers and parameters of chapter 4.3.1. regarding their relevance for the territory concerned.
3. Extend the LPIS' application scheme or feature catalogue to include placeholders for the data elements selected in the previous step.
4. Analyse the data availability for each of these elements and classify them into one of these four categories:
   - Data that can be extracted from the IACS/LPIS content;
   - Data that can be derived from the IACS/LPIS content after dedicated data processing (such as aggregation or change analysis);

- Data that could be captured via farmer's information (e.g., the GSAA);
- Data that have to be retrieved from third parties.

This process would result in an upgraded database structure and a description of the strategy used to populate the placeholders for LULUCF data. It is essentially a conceptual study, requiring collaboration between experts from both the LULUCF and IACS/LPIS domains. These experts may be supported by a database analyst / modeller. The total volume needed is estimated at 30-50 man days (including the internal domain experts).

4.6.2 Extracting available data

This is undoubtedly the most straightforward activity in this process. If LULUCF data is available "off-the-shelf", extraction is simply reduced to a delivery procedure involving:

- The management of dedicated delivery accounts; and
- The creation of a dedicated, user-friendly database query tool.

It is difficult to quantify the precise start-up and running cost of these two activities, but one or two person-months should suffice for the setup, daily operation overhead should be marginal against the already high intensity of daily requests to any IACS/LPIS.

4.6.3 Dedicated processing of IACS/LPIS data

Area for the 3rd approach

The one thing most LPIS's will have to cater for is a spatial representation of the "land use" change,

1. It is obvious and relatively straightforward to start recording such changes from now. This can be done in a manner common to all LPIS implementations
2. However, the possibility to go back to at least 2004 will require custom-tailored data process algorithms, based on either
   - the ability of the system to track back their updates, or
   - (in absence thereof) a meaningful spatial intersection of the various LPIS versions that are present since the start
3. An investigation towards extrapolating the LU area change rates back in time towards 1990 from the time the LPIS or a spatial IACS component existed.

Also here, it is not feasible to specify all activities needed in each of the three procedures. In view of the strong degree of commonality, it is evident that the availability of a common framework would be very helpful to support individual elaborations.

Spatial aggregation for the 2nd approach

Spatial aggregation of the area change towards larger and stable spatial units will be required for any LULUCF process where factor information cannot be obtained at reference parcel or agricultural parcel level.

To minimise the costs that inherently incur by trial and error by each individual system, a common procedure should be agreed upon. Implementing that procedure, defined in IACS terms, would then merely become a special case of data extraction with an added marginal monitoring cost.

Other LULUCF relevant information

Some Member States have data on e.g. fertilisation included in their IACS. These are not necessarily geo-referenced and might provide only a rough measure of average or maximum rate on the level of the whole agricultural holding. Because of this, they are also potentially difficult to differentiate for each land use inside a given holding.

Therefore, it is safe to treat all remaining IACS/LPIS information with LULUCF relevance, as alphanumerical in nature. Specific costs will be incurred to develop, validate and run the database query process.

4.6.4 Extending the farmer's (geospatial) aid application

From 2017, all EU farmers will spatially and digitally declare their crop; most of them already do so now. As a result, an extensive and reliable infrastructure to capture information from the farmer is already in place.

Collecting additional data through this system should be straightforward on condition that the process

1. Is user-friendly: based on an appropriate selection of default entry choices based on crop, region, local condition, previous declarations of the farmer, Farm Advisory System (FAS) know-how, the impact to the farmer should be minimum
2. Collects information that is well separated from the direct payments compliance rules. If the information provided by the farmer cannot be used against him, the farmer should not have an incentive to manipulate that information.

The cost to develop this "add-on" or annex to the geospatial aid application would involve:

1. The cost to define the business rules that make the final application user friendly. This involves a panel of experts familiar with the local practices (essentially, the FAS experts);
2. Extending the software functionality with new screen controls and expanding the IACS database with a separate LULUCF subsystem;
3. Populate the LULUCF data sub-system from the aid application data;
4. Since the entered data are not subject to the compliance control of the direct payments, optionally, a standalone quality management system could be set up. It seems obvious that this would somehow relate to the FAS network.

The first two costs can be considered as a lump-sum for a given territory. Currently, a lot of re-designing of the geospatial aid application is ongoing. In practice, an overall cost of six person-months per system for both tasks seems reasonable.

The third and fourth costs are variable in nature, i.e. they relate to the number and quality of the submitted applications. Still, for farmers and administrations alike, the overhead cost for processing should not be above 10%. Given that there are seven million farmers in the EU, this is, in absolute terms, the most important cost by far.

It is also the most challenging as it involves two or more IACS stakeholders and it has to consider the applicable legislation on data privacy.

However, it is argued that the cost to MS Administrations and the burden to the farmer of developing, maintaining and using a separate system for IPCC LULUCF accounting in addition to the existing IACS systems would be higher. In particular for the farmer, some repetitive data input would be inevitable if there were separate systems.

5. Future steps and potential pitfalls

5.1. Technical aspects

In the previous chapters, we have investigated the usability of IACS/LPIS geospatial and alphanumeric data for LULUCF reporting and accounting. We have analysed the semantic correspondence between the terms and concepts used by both policy domains (IPCC and CAP) and briefly tackled the potential availability of data at national level. We have also identified possible sources of information to fill the gaps that might occur.

The specific methodology that each EU Member State will choose to implement for retrieval and processing of LULUCF-related data from IACS/LPIS will depend on that Member State's choice of the approach and tier level. This choice will be driven by those source/sink categories considered as key ones; by the significance of the sub-categories (biomass, dead organic matter and soil) in relation to the total emissions/removals for the given category; and the availability of country-specific data.

We expect that most member states will be able to use approach 3 methodologies at tier 2 and tier 3 to estimate emissions by source and removals by sink.

This requires geographically-explicit high-resolution land use data, with (emission factors / activity) country-defined coefficients for specific regions and specific land-use categories, where tier 3 / approach 3 combination is applicable/selected. The recently-introduced GSAA could provide an instrument to capture the missing factor data (in particular related to the management and input factors) set up as an informative subsystem.

IACS/LPIS provides land cover/land use information at the level of each individual land unit, represented by the LPIS polygon, this being either the production block itself (agricultural parcel, farmer or physical block) or an administrative unit managed by a third party, such as the topographic block or cadastral parcel. However, IPCC methodologies do not require reporting at the level of the single LPIS polygon. The size of the spatial unit adopted for the LULUCF reporting could be appropriate to address land use variability and to ensure that the given unit can be used consistently over time.

Such spatial unit for LULUCF reporting and accounting can be either a polygon or a grid cell. Inevitably, every LPIS polygon (reference parcel) even belonging to the more temporally stable types (physical block, topographic block, cadastral parcel) is prone to changes and updates. Even so, where a polygon is selected as spatial unit, an aggregation of the individual adjacent reference parcels to a larger, more stable, unit can be implemented – larger land use units (zones) as defined by regionally-managed plans or even the local administrative units (LAU1 and LAU 2 as defined for Eurostat statistics). Here the problem would be the different choices adopted by the EU MS, thus the heterogeneity of the spatial units used for LULUCF reporting.

The grid model allows land monitoring to utilise and merge existing data sources by using a regular, fixed and common geometry as an interface. The sources can be the LPIS itself, or national high spatial resolution maps and registers as well as other high-resolution spatial resolution data, e.g. the Copernicus Land Services. Statistics and analysis as well as modelling exercises are fairly easy to implement in grids due to the regular shape and size of the grid units. The grid approach is well suited for the visualisation in small cartographic scale and useful for making detailed and complex queries.

On the negative side, the geometry of the grid model is unfamiliar for many users and does not correspond to any land cover or land use "objects" in the physical world.

The two most important issues to address are grid resolution and choice of attributes. Future implementation of a grid approach for LULUCF will largely depend on the proper balance between the choices for a common grid resolution and attribute availability at pan-European level.

In chapter 4.2.1 we showed that due to correspondence between the IPCC categories and the LPIS land cover types representing cropland and grassland, in most cases the extraction of IPCC land use data from the LPIS through semantic mapping and semantic/spatial aggregation can be relatively straightforward. The main issues that may need to be addressed further are the specificities of certain land cover/land use types (e.g. temporary grassland, or land parcels with "permanent grassland under established local practices" defined at national level).

On the other hand, completeness of the data on land use in IACS/LPIS (that is, the fact that IACS/LPIS only contains land parcels of agricultural holdings that apply for CAP support) should not pose major issues. A statistic approach is used, e.g. also in the case of forest inventories for the forest-related emissions and removals in LULUCF reporting and accounting. In case of data gaps in the spatial or thematic coverage, the information related to the land use factor can be retrieved through sampling, instead of complete enumeration. The statistical coverage of the LPIS is in any case much larger than that of all forest inventories used by Annex I countries and approved and validated on the IPCC level.

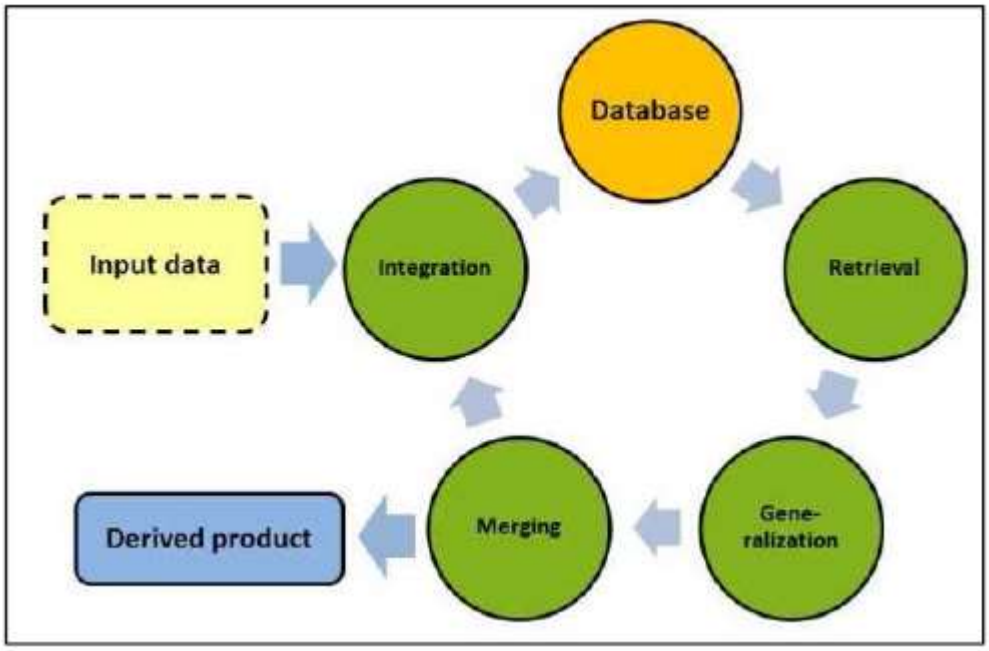

Figure 7 - The iterative data integration and generalisation process identified as the common structure used in European bottom-up approaches to land monitoring (from Deliverable 5 of HELM project)

Another important issue would be the gaps of data for the required time series. These gaps can be filled either by external data sources (thematic datasets, farmer application), or by dedicated analyses of archive remote sensing data (satellite images, archive orthophoto). Most EU Member States have specific spatial dataset holding information of environmentally sensitive grasslands, including those under NATURA 2000 and those situated in peat or wetlands. These areas were indeed collected largely though the graphical information provided by the farmers themselves.

Chapter 4.6.5 provided references to an EEA project that tackles the issue of generation of common pan-European land related spatial data from detailed and heterogeneous national datasets through generalisation and aggregation. This iterative process proceeds through several steps: integration of data into a common data structure; data retrieval; generalisation; and merging (Figure 7).

5.2. Regulatory and other aspects

Member States that were contacted highlighted the need for a common approach across the EU, and for the necessary changes in legislation or in implementation and management guidelines to be made on the EU-level.

The Commission could provide guidelines or clarification, or assess the need for any revision of the legislation, to tackle:

1. The extension and use of the GSAA for additional data collection from the farmer;
2. Issues surrounding data access and data use, and helping to highlight to Member States which IACS data are "personal" and which are not.

As far as data protection and use are concerned, it would be necessary to ensure that relevant data held within IACS, including the LPIS, can be used for other objectives and by other entities if public interest prevails. Third parties (e.g. statistical offices, organisations responsible for IPCC reporting and accounting) should be able to store personal data if this is necessary to fulfil their tasks and obligations (e.g. for statistical purposes) or to conduct all necessary processing for monitoring and evaluation.

It was suggested that it should be possible that the "processing of aggregated data" in Article 117 (2) of Regulation 1306/2013 refer only to the eventual publication of aggregated results, allowing access and processing of data in a non-aggregated form. This would e.g. enable the use of LPIS for approach 3 / tier 3 methods of georeferenced tracking of land-use change on the parcel level.

That IPCC reporting and accounting should be explicitly considered part of the statistical purposes referred to in Regulation (EU) No 1306/2013.

EU coordination should help ensure that the deletion of land use data in the IACS system after ten years is considered in conflict with the IPCC reporting requirements, which relies on tracing land use and land-use change back to 1990.

There is clear potential and also strong political will to make best use of the vast information in the IACS data for IPCC reporting and accounting. The EU should take measures to make this possible and smooth.

Straightforward guidelines on data access and use should be shared by all authorities responsible for the IACS system, to those responsible for IPCC reporting and accounting, and to the organisations involved in the practical handling of IACS data (payment agencies) as well as any of those implementing the IPCC reporting and accounting tasks.

5.3. Recommendations to DG Climate Action

We advise DG Climate Action to pursue the following priority actions:

1. Liaise with DG Agriculture and with MS LPIS Custodians and relevant MS Institutions, both in central governments and – where implementation is decentralised (e.g. Germany, Italy, UK) – also on the level of regional authorities, in order to address the issue of data protection and privacy, devising solutions so that data processing can be performed for IPCC LULUCF accounting before data is aggregated;
2. Organise a joint working group with MS technical services in charge of IPCC LULUCF reporting and those in charge of IACS / LPIS;
3. Draft specific guidelines on data use, in liaison with DG Agriculture;
4. Develop technical guidance on the basic structure of a data interface, together with all relevant actors from the Commission and the MS;
5. Liaise with DG Agriculture and with MS Administrations that are currently developing or beginning to implement the GSAA, in order to jointly develop a common framework to collect additional data for LULUCF accounting purposes.

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IPCC, Good Practice Guidance for LULUCF reporting and accounting

MIS-ETC-CODE171 PROJECT – Common Strategy for Sustainable Territorial Development of the cross-border area Romania-Bulgaria WP3 Development of common resources for territorial planning analysis and strategy

Weiss P, Freibauer A, Gensior A, Hart K, Korder N, Moosmann L, Schmid C, Schwaiger E, Schwarzl B (2015), Guidance on reporting and accounting for cropland and grassland management in accordance with Article 3(2) of EU Decision 529/2013/EU, Task 3 of a study for DG Climate Action: 'LULUCF implementation guidelines and policy options', Contract No CLIMA.A2/2013/AF3338, Institute for European Environmental Policy, London.

List of abbreviations and definitions

AFOLU	Agriculture, Forestry and Other Land Use
BPS	Basic payment scheme
CAP	Common Agricultural Policy
CP	Commitment period
CM	Cropland management
CO_2-eq	CO_2-equivalents
CLC	CORINE Land Cover
EC	European Commission
EFA	Ecological focus area
EU	European Union
GAEC	Good Agricultural and Environmental Condition
GM	Grazing land management
GSAA	Geo-spatial aid application
GPG-LULUCF	Good Practice Guidance for LULUCF reporting and accounting
FAS	Farm Advisory Service
IACS	Integrated Administrative and Control System
IPCC	Inter-governmental panel on climate change
JRC	Joint Research Centre
KP	Kyoto protocol
LFA	Less-favoured areas
LPIS	Land Parcel Identification System
LULUCF	Land Use, Land-Use Change and Forestry
MS	Member State(s)
SOC	Soil organic carbon
UN	United Nations
UNFCCC	United Nations' Framework Convention on Climate Change

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