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Evaluating the Suitability of the Land Parcel Identification System for Assessing Land Use and Land Use Change-Related Greenhouse Gas Emissions

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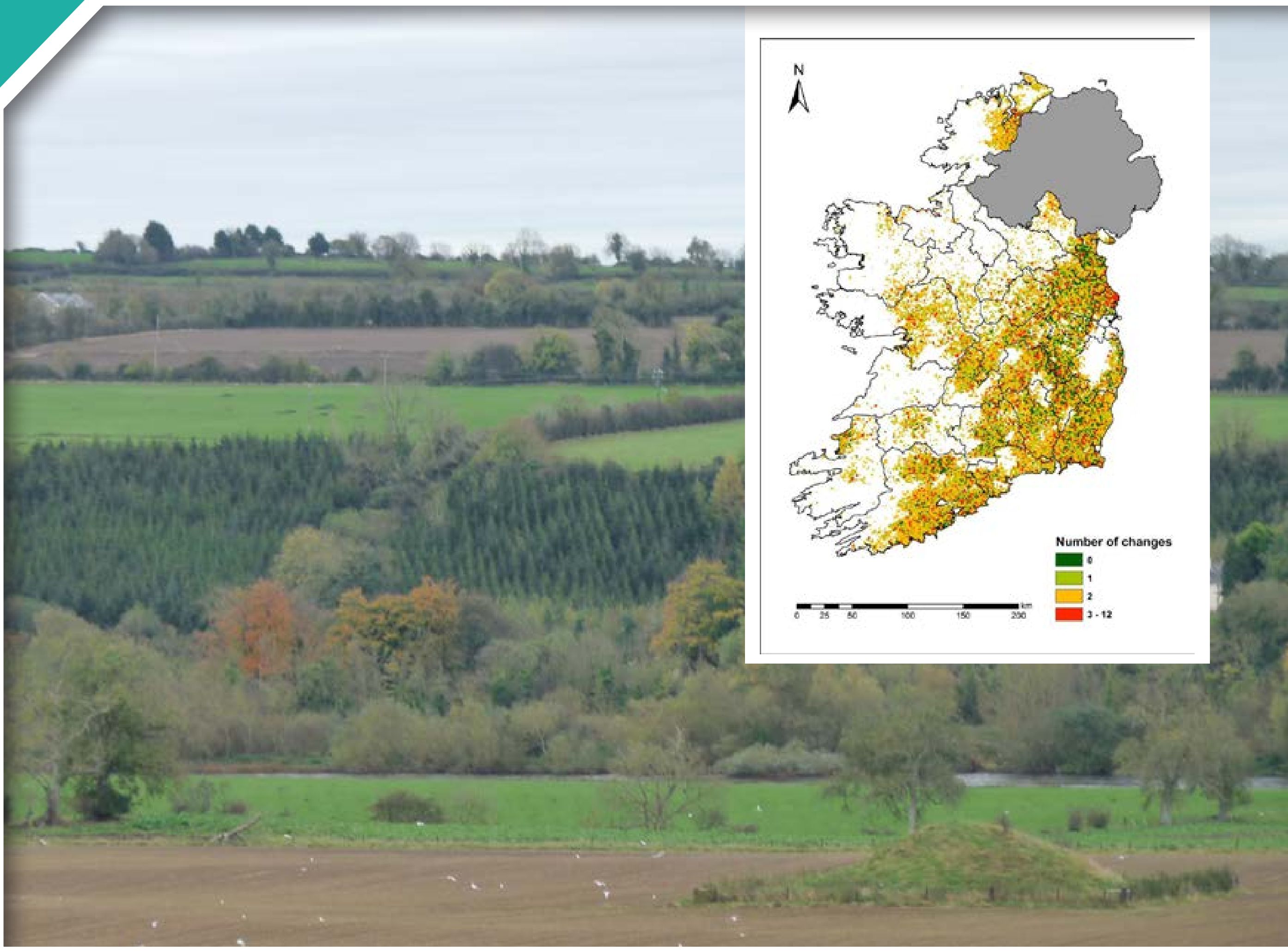

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Government of Ireland

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- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

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EPA RESEARCH PROGRAMME 2014–2020

Evaluating the Suitability of the Land Parcel Identification System for Assessing Land Use and Land Use Change-related Greenhouse Gas Emissions

(2012-CCRP-FS-9)

Prepared for the Environmental Protection Agency

by

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The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

Land use and land use change have a significant impact on national greenhouse gas (GHG) emissions and are therefore an integral part of national GHG reporting, as laid out by the United Nations Framework Convention on Climate Change. In Ireland, land use and land use change reporting is currently based on total national agricultural area data provided by the Central Statistics Office. Although the data provide a comprehensive overview of the total area per crop each year, assessing the trajectory of land use change can be calculated only using socioeconomic models, which introduce a degree of uncertainty.

The Land Parcel Identification System (LPIS) is a high-resolution agricultural database that was developed to assist farmers and authorities with applications for agricultural subsidies as part of the European Union Common Agricultural Policy. The system is based on agricultural parcels (a single crop type on a single farm) as reference parcels and is updated annually, providing a high spatial and temporal resolution land use database.

As LPIS has not been designed for the purpose of land use/land use change assessment for GHG reporting, a number of limitations can be expected. The aims of this project were to:

- assess the suitability of LPIS for GHG-related land use/land use change assessment;
- implement modifications to improve the suitability of LPIS for GHG-related land use/land use change assessment;
- develop tools to modify LPIS and to assess annual land use and land use change.

The initial analysis showed that LPIS has a number of limitations because of its original purpose as a single farm payment support tool. The main limitations are parcel duplication as a result of commonage, unrealistic parcels created as administrative boundaries, and changing parcel outlines over time, which impact on land use change analysis. Furthermore, a number of reporting issues exist, namely inconsistent reporting on grassland management types (i.e. intensive vs extensive grassland), inconsistent reporting on forestry and buildings and reporting of multiple land uses within a single parcel.

Spatial limitations can be solved using tools developed in this project, as well as pre-existing tools within ArcGIS. Reporting limitations need to be taken into account and can potentially be solved by using ancillary data such as the Integrated Forest Information System (IFORIS) dataset.

In conclusion, LPIS has strong potential to significantly improve land use and land use change assessment with regard to national GHG reporting. However, a number of limitations need to be taken into account.

1 Introduction

Current changes in global climate are recognised as one of the most serious threats to human wellbeing, as well as the natural environment (IPCC, 2014a,b). The link between anthropogenic greenhouse gas (GHG) emissions and climate change is well documented (IPCC, 2013). Dynamics linked to land use and land use change (LULUC) have been recognised as a major factor in the global carbon cycle (Schimel, 1995) and the effects on global carbon stocks have been well studied (Guo and Gifford, 2002). The major sources of carbon release to the atmosphere are the loss of above- and below-ground biomass, as well as soil organic carbon as a result of ongoing soil disturbance (Schlesinger, 1986; Roberts and Chan, 1990). In the decade from 1990 to 2000, global emissions as a result of LULUC and forestry have been estimated to be between 0.5 and 2.7 Gt C year^{-1} (Smith, 2008). Since the mid-19th century, land use change has been estimated to be a major global carbon source, adding about 156 Pg of carbon to the atmosphere, with the majority being lost as a result of the conversion of forestry to agriculture, as well as changes from grasslands to croplands (Houghton, 2003). Although the overall dynamic is currently dominated by GHG emissions, land use change also has the potential to act as a carbon sink, as conversions from cropland to grassland or forestry increase above- and below-ground biomass and can foster soil carbon sequestration (Post and Kwon, 2000).

Although the effects of changes in land use have been well studied, recent research into the impact of changes within certain land use types shows significant impacts on carbon stocks. Different farming practices, such as tillage practices, use of cover crops, grazing intensity and silage cutting, have been shown to have significant effects on carbon stocks, mainly because of changes in soil organic carbon content (Post and Kwon, 2000; Jones and Donnelly, 2004), with a high potential for long-term carbon sequestration (DEFRA, 2001; Soussana *et al*., 2004). Conant (2010) describes four major methods that increase carbon stocks in grasslands: (1) a change in grazing management from maximum offtake to maximum production, (2) sowing improved species, especially nitrogen-fixing plants, (3) increasing direct inputs of organic water, fertiliser or organic matter and (4) restoring degraded grasslands. Methods to increase the carbon stock in croplands are the use of cover crops, the inclusion of grass into the rotation cycle and the use of low- or no-till practices. The effect of low- and no-till practices on soil organic carbon pools is, however, strongly dependent on soil properties and climate conditions and therefore further detailed data are required for assessment (Soane *et al*., 2012).

The impacts of LULUC on GHG dynamics are recognised in the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC) and are therefore part of the national GHG budgets that have to be provided by Annex I countries (UN, 1998). A tier-based methodology for recording and assessing LULUC types and their impact on the national GHG inventory is provided in the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC, 2003), which has been incorporated into the *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006). The guideline specifies internationally recognised methodologies for use by states to assess their GHG inventories and report them to the UNFCCC.

In Ireland, LULUC has been reported to account for an uptake of 2357.43 Gg CO_2eq (carbon dioxide equivalent) (Duffy *et al*., 2011). Currently, LULUC reporting is based on national statistical data provided by the Central Statistics Office (CSO). As the data do not contain any spatial references, analysis of the trajectory of land use change uses complex functions based on socioeconomic factors and a set of underlying assumptions (O'Brien, 2007). Apart from the uncertainties associated with land use change, this also introduces limitations with regard to underlying land use dynamics, i.e. if equal amounts of land enter and exit a specific land use within the same year, the total area will remain static, masking land use change. Furthermore, the available data currently allow only for the use of tier 1 methodology for estimating potential GHG sinks and sources related to LULUC, as data required to calculate site-specific emission factors cannot be extracted without geospatial information.

It is therefore recommended that the accuracy of land use mapping to assess transitions to, from and within agricultural systems is increased using novel measuring techniques. On a long-term basis this will help to reduce the error in the national GHG inventory and ultimately support progression to a higher tier methodology.

1.1 The Land Parcel Identification System

The Land Parcel Identification System (LPIS) was developed as part of the European Union's (EU) Common Agricultural Policy (CAP). The system is the key component of the Integrated Administration and Control System (IACS) for assigning area-based agricultural subsidies. It was developed as a spatial register in which farmers can identify any agricultural parcel when applying for financial aid schemes.

The system is based on reference parcels that are mainly created from the most up-to-date orthophotography, but which may also be created from other sources, such as cadastral maps, land distribution plans and topographical maps. Depending on the data sources, LPIS is created as one of four main types, determining the minimum mapping unit:

1. agricultural parcel – representing single crop groups on single farms;
2. farmer block – representing one or multiple crop groups on a single farm;
3. physical block – representing one or multiple crop groups on one or multiple farms;
4. cadastral parcel – representing land cadastres, which may not match agricultural patterns.

LPIS is regularly assessed to determine if reference parcels match the underlying data and, if necessary, updates are carried out.

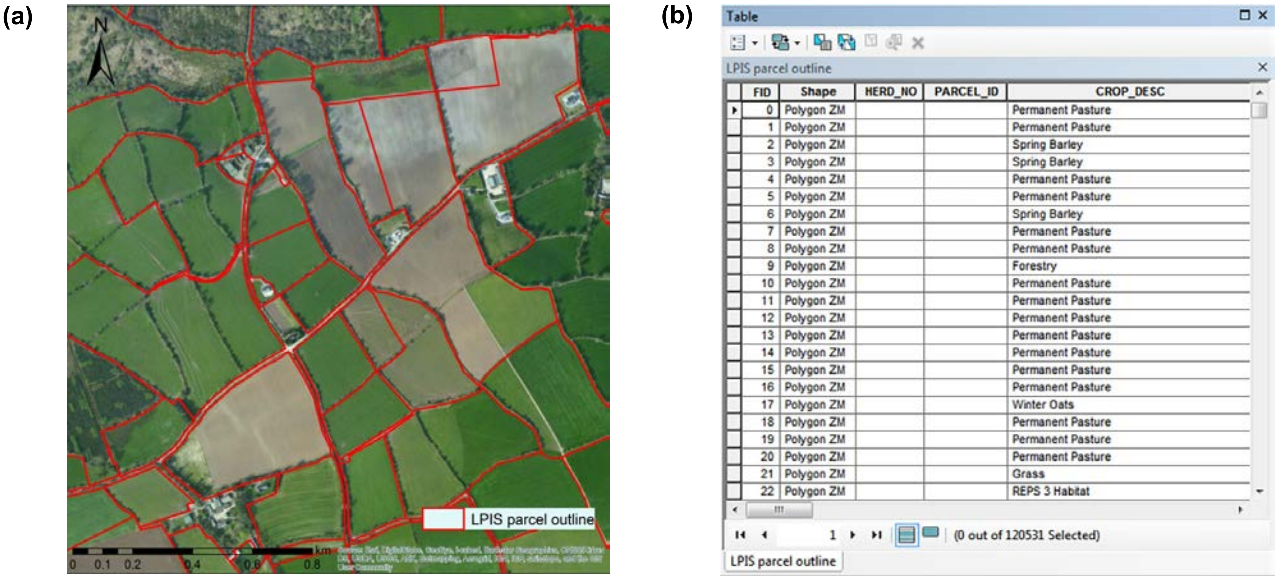
In Ireland, LPIS is based on agricultural parcels – it is based on the historical Ordnance Survey of Ireland (OSi) 25-inch map series and, to a smaller degree, on the 6-inch map series (< 10% of the area). The licence is held by the Department of Agriculture, Food and the Marine. The official starting date is 1 January 1996; however, the dataset is considered complete from 2000 onwards.

Because of the use of agricultural parcels as the minimum mapping unit, LPIS has a very high spatial and temporal resolution, giving it a strong potential for improving LULUC assessment. The major improvements are:

- The ability to locate current land use each year. This allows overlaying of land use data with ancillary information such as management data, soil properties and climate conditions. This information is crucial for higher tier GHG reporting as it requires specific site information to assign specific emission factors (tier 2) or to conduct site-specific modelling (tier 3).
- The possibility of tracking the trajectory of ongoing land use change. Directly tracking land use change events reduces the reliance on models when assessing land dynamics. It also identifies possible underlying land dynamics, i.e. when equal amounts of land change between two different types of land use in a single year. Both land uses would show a constant area and therefore land use change would not be detected.

Additionally, LPIS as a tool for assisting the assignment of agricultural subsidies based on land use area is upgraded annually and should theoretically identify any land use change event if it leads to a change in subsidy eligibility. This allows for a much higher temporal resolution than the use of land cover data, such as CORINE or LUCAS data. Figure 1.1 shows the spatial and non-spatial data presented by LPIS.

However, there are limitations associated with LPIS, which originate from the fact that LPIS was designed for a specific purpose, i.e. assisting farmers and authorities with agricultural subsidies. As such, the build of the database may not meet all requirements for LULUC assessment with regard to national inventory reporting. Furthermore, as it is an agricultural database, information on non-agricultural land uses is limited.



FID	Shape	HERD_NO	PARCEL_ID	CROP_DESC
0	Polygon ZM			Permanent Pasture
1	Polygon ZM			Permanent Pasture
2	Polygon ZM			Spring Barley
3	Polygon ZM			Spring Barley
4	Polygon ZM			Permanent Pasture
5	Polygon ZM			Permanent Pasture
6	Polygon ZM			Spring Barley
7	Polygon ZM			Permanent Pasture
8	Polygon ZM			Permanent Pasture
9	Polygon ZM			Forestry
10	Polygon ZM			Permanent Pasture
11	Polygon ZM			Permanent Pasture
12	Polygon ZM			Permanent Pasture
13	Polygon ZM			Permanent Pasture
14	Polygon ZM			Permanent Pasture
15	Polygon ZM			Permanent Pasture
16	Polygon ZM			Permanent Pasture
17	Polygon ZM			Winter Oats
18	Polygon ZM			Permanent Pasture
19	Polygon ZM			Permanent Pasture
20	Polygon ZM			Permanent Pasture
21	Polygon ZM			Grass
22	Polygon ZM			REPS 3 Habitat

Figure 1.1. Representation of LPIS. (a) LPIS polygons representing the spatial aspect of the LPIS data; (b) LPIS attribute table showing an example of the non-spatial data provided in LPIS ("Herd Number" has been removed because of General Data Protection Regulation concerns). Background image source: Esri, Microsoft (UC-G) image captured on 29 March 2012, as shown in the 20 February 2014 version of the World Imagery map.

1.2 Main Objectives

The initial project had three main objectives:

1. To assess the suitability of LPIS for GHG-related LULUC assessment. This objective comprised a general analysis of the database, including the spatial framework and the information contained, as well as a detailed analysis of its limitations with the goal of either compensating for or quantifying the uncertainty introduced by them.
2. To develop methodologies to best address the limitations, with the goal of adapting LPIS for GHG-related LULUC assessment. The aim was to provide a set of tools that can be applied to LPIS annually.
3. To use cropland as a case study, not only to assess the advantages of using LPIS for LULUC assessment but also to highlight best practice when working with the database to avoid inaccuracies.

In addition to the main objectives, a number of side tasks were carried out:

- an initial assessment of the possibility of crops being grown on organic soils in Ireland;
- an assessment of crop stubble burning in Ireland;
- a comparison of forest distribution recorded in LPIS and the Forest Inventory and Planning System (FIPS);
- an analysis of agricultural land used for housing using LPIS and the GeoDirectory database.

2 Using the Land Parcel Identification System to Assess Land Use and Land Use Change-related Greenhouse Gas Emissions

To assess if LPIS is suitable for assessing GHG emissions related to LULUC, two main aspects of LPIS have to be examined: (1) whether or not the non-spatial data provided in LPIS are sufficient to assess site-specific GHG emissions and (2) whether or not the spatial accuracy and precision are good enough to identify sites and to track those sites through time. This chapter first describes the data provided and then the suitability of the data to assess land use change-related GHG emissions.

2.1 Data Provided in LPIS

The LPIS data were made available to the EPA as ArcGIS polygon shapefiles (ERSI, Redlands, CA, USA), with each polygon representing an agricultural parcel. The exact specifications of the LPIS data are listed in Table 2.1.

The data available for each parcel vary slightly between different years; however, the basic information provided with each parcel stays constant. The basic information provided is as follows:

- LNU_PARCEL (or PARCEL_ID): an alphanumerical identifier (ID) for each entry in LPIS. The ID follows a hierarchical system, abbbccddd, as follows:
  - Letter A–Z: representing counties in alphabetical order. The county ID represents the county of the landowner and therefore may not be geographically correct.
  - Numerical: electoral district as of 1995/96 (not current district electoral divisions).
  - Numerical: townland.
  - Numerical: sequential parcel number (001–999). The sequential parcel number for the Aran Islands is > 999.
- HERD_NUMBER: an alphanumerical ID indicating land ownership.
- CROP_DESC: land use description (see section 2.2.1 for further information)
- Area: the area of the polygon in hectares. The area is measured from the centre of the respective boundary feature (e.g. hedgerow) and does not represent the actual area of the specific land use.

The following additional information is not available for all years: COMMONAGE (yes/no indication) and CROP_S2 (additional land use).

2.2 Suitability of LPIS for Greenhouse Gas Assessment

2.2.1 Suitability of the meta-data

2.2.1.1 Parcel identification

A numerical ID of parcels is an important aspect of LPIS. As LPIS data for each year are represented by a separate file, the ID is important for tracking specific parcels over time. Although spatial overlays are also possible, they require high computing power for a database as large as LPIS.

The provided ID is constant if a parcel does not change outline over time; however, any change to a

Table 2.1. Specification of the LPIS data for Ireland

Type	ArcGIS polygon shapefiles
Projection	Irish National Grid (IG1965)
Minimum mapping unit	Agricultural parcel (as defined by physical boundaries or land use)
Number of polygons	Between 827,514 and 1,278,903 depending on reporting period
Update cycle	Annually

parcel will result in a new ID being assigned. This is problematic for two reasons.

1. LPIS does not contain information about such changes (i.e. the old/new ID). This complicates the identification of land use change for parcels that change outline over time.
2. The change in ID does not distinguish between corrections within the LPIS framework (corrections of parcel outlines to better fit parcel boundaries) and real-world changes (changes in field parcel boundaries entered into LPIS).

Because of these limitations it is recommended that a new parcel ID is created following a set of criteria to distinguish corrections within LPIS from real-world changes. A tool to assign IDs was developed and is described in section 4.3.

2.2.1.2 Land use

The CROP_DESC attribute reports the land use in each parcel. All land uses assigned in the database are listed in Table 2.2. To assess the accuracy of the land use descriptions within LPIS, a number of methods were applied.

Comparison of reported land use national statistics

Compared with land use data recorded by the CSO for the years 2004–2011, the total area recorded as agricultural land in LPIS is 22.0% ± 9.2% larger. Areas of grassland and arable crops recorded in LPIS datasets are 16.9% ± 8.1% larger and 9.9% ± 5.1% smaller, respectively, than those reported by the CSO for the respective year. The reason for this difference

Table 2.2. Crop descriptions used in LPIS[a]

LPIS category	Summarised category
Energy crop, *Miscanthus sinensis*, reed canary grass, switchgrass	Bioenergy
Barley, buckwheat, flax, fodder barley, fodder wheat, forage rape, hemp, linseed, maize, oats, oilseed, rye, spring barley, spring oats, spring oilseed rape, spring wheat, triticale, variety name,[b] wheat, winter barley, winter oats, winter oilseed rape, winter wheat	Cereal
Forestry, forestry 2010, forestry 2011, forestry 2012, forestry eligible, forestry setaside, REPS 4 new woodland, woodland	Forestry
100% destocked area, clover, designated habitat, foliage, forage, forage riparian area, former REPS 3 new habitat, former REPS 3 new habitat, former REPS 4 new habitat, grass, grass seed, grass silage, grassmeal, habitat, hay, linnet habitat, mixed grazing, permanent pasture, REPS 3 habitat, REPS 3 new habitat, REPS 4 habitat, REPS 4 new habitat, REPS 4 planted buffer zone, REPS landscape feature, rough grazing, scrub, species-rich grassland, traditional sustainable grazing, traditional hay meadow	Grassland
Arable habitat, arable silage, *Camelina*, certified seed, fallow, flowers, fruit, green cover, non-food, nursery, plumbshot, regeneration, setaside, sunflower, sweet lupins	Other crops
Invalid crop, landscape feature, other, riparian area, riparian zone, rocky outcrop	Other
Beet, early potatoes, fodder beet, forage rape, maincrop potatoes, potatoes, seed potatoes, sugar beet, swede, turnips	Root crops
Access road/roadways, building, farm road, farmyard, gardens, quarry, recreational area	Settlement
REPS compliance, unknown, wild bird cover	Inapplicable
Beans, kale, peas, vegetables, rocket, mangolds	Vegetables
Lake/waterway/pond	Water
Bog	Wetland
Orchard, REPS 4 orchard, short rotation coppice, willow	Woody crops

[a]For clarity, the crop descriptions are grouped into overarching categories.

[b]Variety names are Accord, Acrobat, Activ, Aladin, Alaska, Aligator, Almea, Arabella, Ark, Avant, Basalte, Beryl, Bingo, Boni, Briol, Bristol, Bullet, Ceres, Corniche, Ebony, Ecudor, Falcon, Felix, Fidelio, Forte, Galaxy, Garrison, Granit, Hanna, Hybridol, Idol, Inca, Iris, Jaguar, Kabel, Kulta, Liaison, Libravo, Limpet, Lineker, Madora, Maja, Manta, Mars, Millet, Nimbus, Oak Summit, Ole, Orelia, Orion, Orphee, Pactol, Pallas, Polo, Prelude, Quartz, Rafaela, Rally, Rapier, Rosette, Sabrina, Senta, Silex, Sisu, Star, Starlight, Susana, Symbol, Synergy, Unica, Valo, Vega, Vivol, Wotan and Zorro.

REPS, Rural Environment Protection Scheme.

is most likely that the area information available in the current LPIS version is the actual parcel size and therefore includes margins and hedgerows and not just actively farmed land.

The comparison of the LPIS data with the CSO data also showed a major underestimation of the amount of land reported as "rough grazing". The reason for this underestimation is that rough grazing does not fall into a separate category for subsidies. As a result, farmers may report rough grazing but are not required to. Therefore, rough grazing may often be reported as "grassland" or "permanent pasture". To avoid bias in grassland types it is recommended that all types of grassland are summarised in a single category.

Visual assessment of land use reported

An attempt was made to assess if the land use descriptions were accurate for croplands and grasslands by overlaying a subsample of 1250 parcels with the OSi orthophotography maps from 2000. For croplands the land use observed in the orthophotography matched the land use described (92.4% matching land use).

For grasslands the match was lower (72.24%); however, in both cases the mismatch was mainly caused by LPIS polygons containing multiple parcels, with the majority of the observed land use matching the crop description in LPIS. This method is generally subject to significant error as visually identifying land use from aerial photography is difficult, with very limited possibilities to distinguish land use types within croplands and grasslands.

Comparison with additional sources of land use data

Integrated Forest Information System

To assess the accuracy of forestry reported in LPIS, the database was overlaid with the Integrated Forest Information System (IFORIS) spatial database. The IFORIS database contains the most up-to-date information on forest cover in Ireland. Although LPIS does contain information on forestry, it is assumed that, because forestry is not eligible for the single farm payments covered by LPIS, the area of forestry within the database significantly underestimates the total forest area in Ireland.

Comparing the parcels in the IFORIS dataset with LPIS data for the year 2011 showed that 21.1% of the IFORIS parcels reported for 2011 were not covered within the LPIS dataset. Of the IFORIS parcels that coincided with the LPIS parcels, 14.2% reported land uses other than forestry in LPIS. The majority of these parcels, however, are reported as forestry in 2012, indicating a temporal discrepancy between LPIS and IFORIS reporting. To assess the type of error (whether the misreporting occurs in the IFORIS or the LPIS dataset), the parcels in question were overlaid with aerial imagery from the ArcMap World Imagery service. In 95.6% of cases the aerial image showed forestry in the parcels and in 4.4% of cases no forestry was visible on the images.

To assess compatibility between the IFORIS and the LPIS shapefiles the same criteria were used as when assessing parcel stability when comparing consecutive years within LPIS (see Chapter 4). An IFORIS parcel and a LPIS parcel were therefore defined as being not significantly different when the parcels showed (1) a <5% difference in their outline and (2) a less than 12-m shift of their centroids. The initial selection of LPIS parcels that coincide with IFORIS parcels was carried out by selecting those LPIS parcels that contain the centroid of any IFORIS parcel. The analysis showed that <0.5% of the coinciding parcels show significant differences – in the majority of cases either the different parcels are very small (<0.1 ha) or single parcels within either dataset are represented by multiple parcels in the other.

The results suggest that LPIS information on forestry is not sufficient for an in-depth analysis of land use dynamics between forestry and other land uses because of (a) the large mismatch between the area covered in IFORIS and the area covered in LPIS and (b) the high number of parcels identified as forest in IFORIS and satellite imagery that were not reported as such in LPIS. However, the structure of the IFORIS dataset provided by the Department for Agriculture, Food and the Marine shows sufficient compatibility with the LPIS dataset to integrate the two datasets to expand on information on land use dynamics linked to forestry.

GeoRegister

Furthermore, to assess the quality of information on housing in LPIS, the database was overlaid with the

GeoRegister database. The GeoRegister provides information on the location of buildings in Ireland. As LPIS does not contain comprehensive information on buildings, assessing land use change with regard to these structures is subject to high levels of inaccuracies.

For the assessment two assumptions were tested: (1) parcels containing buildings in a specific year are generally not covered by LPIS as the database is specifically devised for agricultural land uses and (2) if parcels with buildings are reported in LPIS they should be described as such. As the database does not contain information on the construction date of the buildings, it is difficult to test these assumptions. Therefore, a statistical approach was applied for the initial analysis. Parcels that coincided with an address entry in the GeoDirectory but that were described as something other than "building" were assumed to have not been built yet. To test this assumption a subset of 800 parcels for the year 2000 that coincided with GeoDirectory entries but that were not described as "building" were assessed using aerial imagery from the relevant years. Of the 800 samples, about 41.3% of the buildings had not yet been built in 2000 and 34.8% of the buildings had already been built but were not identified in LPIS. The remaining subsamples could not be assessed properly as the images either were clouded or did not provide the required resolution for parcel-specific land use identification.

2.2.2 *Suitability of the spatial aspect of LPIS for GHG assessment*

2.2.2.1 *Spatial accuracy*

The initial screening of the LPIS datasets showed that LPIS is a comprehensive database, covering the agricultural area of Ireland. An overlay with aerial photos (ESRI World Imagery, ArcGIS 10.1 basemap) showed a very good fit of the outlined parcels with boundary features in the remote imagery (e.g. hedgerows, walls, obvious crop changes).

The initial survey also showed a number of very large parcels covering hectares of ocean, mostly located off the west coast of Ireland. These parcels can lead to an overestimation of the agricultural area of 1443.1 ± 1378.0 km^2. According to Mallon Technology, these parcels are administrative boundaries used to cover island groups off the west coast.

Analysis of Table 2.3 shows a varying number of spatial duplications of parcels. This generally represents commonage, meaning parcels worked by multiple farmers, often occurring in areas of rough grazing. Although the number of parcels duplicated is relatively low compared with the overall number of agricultural parcels represented in LPIS, many parcels are duplicated multiple times, leading to a large error in the total agricultural area. The overestimation amounts to 20,917.7 ± 7157.6 parcels showing one or multiple duplicates, leading to an overestimation of the agricultural area by 58,194.2 ± 11,578.4 km^2 (in comparison, the total area of Ireland is 70,273 km^2).

Both administrative boundaries and duplicated parcels show large standard deviations when averaged over all of the available years of data. In the first case this is due to the size and number of duplications of some large parcels that are not present every year; in the latter case it is due to the highly varying numbers of duplications affecting the overall area. A summary of the errors caused by large parcels and duplications each year is presented in Table 2.3. Examples are presented in Figure 2.1.

LPIS contains 827,514 to 1,278,903 parcels, making the datasets for each year extremely large (average size 2 GB per year). The computing power required for geospatial operations on LPIS databases is therefore too large for most normal office computer set-ups. In

Table 2.3. Area of duplicated parcels and large parcels

Year	Area (km^2)	
	Duplications	Administrative boundaries
2000	53,035.2	804.0
2001	59,523.0	2893.9
2002	87,359.3	4905.1
2003	54,146.8	2693.3
2004	44,378.7	2727.2
2005	54,863.1	605.1
2006	55,206.3	830.4
2007	58,377.3	838.8
2008	68,028.4	1007.6
2009	72,082.6	1052.5
2010	50,728.2	300.2
2011	50,481.7	0
2012	48,314.5	101.7

(a) (b)

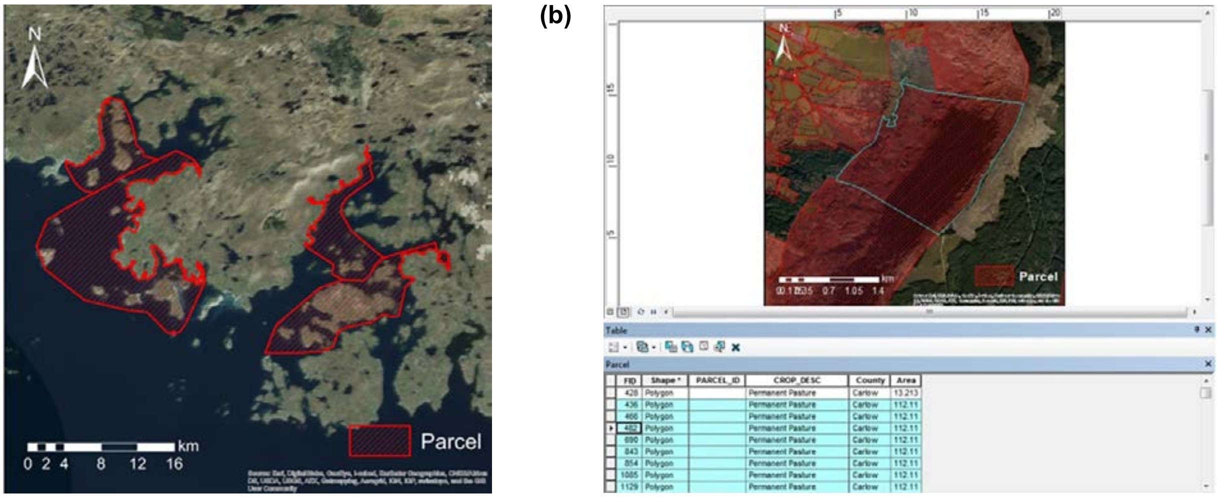


Figure 2.1. Examples of (a) large unrealistic parcels and (b) parcel duplication. Background image sources: (a) Esri, World Imagery captured on 15 January 2011 by CNES/Airbus DS, as shown in the 20 February 2014 version of the World Imagery map; (b) Microsoft (UC-G) image captured on 6 November 2011, as shown in the 20 February 2014 version of the World Imagery map.

order to reduce the required computing power it is recommended to divide LPIS into subsections.

This division can be adapted to specific requirements, following, for example, a simple grid, administrative boundaries or environmental zones. For the analyses carried out in this study, LPIS was divided following county boundaries as these are reproducible and small enough to significantly increase computing speed. This procedure is described in Chapter 4.

2.2.2.2 Changing parcel outline

The initial inspection of LPIS showed that reference parcels may change their outline over time. To accurately assess land use change the changes in parcel outline need to be taken into account. As described in section 2.2.1, the changes cannot be traced using the data provided, and changes in the ID provided do not distinguish between real-word change and corrections within LPIS.

Although real-world changes reflect potential changes in LULUC-related GHG budgets, corrections of LPIS reference parcels do not impact GHG dynamics. Therefore, it is important to differentiate the type of change being considered. In order to better understand parcel outline dynamics, a new numerical ID was assigned (see section 4.3 for a specific tool description).

The methodology overlaid LPIS datasets for two different years and analysed the changes in overlapping parcels. In order to quantify potential changes in parcel outline over time, two criteria were used: (1) area difference and (2) centroid distance. These criteria are based on the assumption that corrections to the database will generally be small changes in parcel outline, whereas on-farm changes, such as the splitting of a field into two land uses, will lead to a major change in parcel shape. If area difference and centroid distance remained below a given threshold, a parcel was assumed to be "unchanged" (no on-farm change) and the given ID was retained; if either of the criteria was larger than the threshold the parcel was assumed to have undergone on-farm change and a new ID was assigned. For the present analysis a maximum change in area of 5% of the parcel area and a maximum shift in the parcel centroid of 12 m were used to distinguish between on-farm change and LPIS corrections.

New IDs had been assigned and these were used to assess overall parcel stability. Generally, parcel stability between consecutive years was very high (on average, 90.5% ± 3.2% of the parcels in every year were also present in the previous year). However, when looking at the whole time frame, only 48.5% ± 7.2% of the parcels, representing 57.8% ± 0.7% of the area recorded in 2000, were still present in 2012. The remaining parcels were newly added parcels, parcels that were removed from LPIS or parcels that had changed between the two years (i.e. that were split, were merged or had a large area removed or added).

In addition, the tool records the parcel ID history of every given parcel. If a parcel changes outline between two different years the initial ID(s) will be noted in the subsequent year and vice versa, making it possible to track each given parcel by its ID, even if it changes because of outline changes. This also allows for a better understanding of the type of outline change:

- parcels changing from a single ID to a single ID: simple outline change;
- parcels changing from a single ID to multiple IDs: split;
- parcels changing from multiple IDs to a single ID: merge;
- no subsequent ID: parcel removed;
- no initial ID: new parcel.

The number of parcels undergoing each type of change, following the set criteria for parcel outline change, is summarised in Table 2.4. Because of the criteria introduced to define parcel stability, parcels may show small differences in area between two different years, even though they are defined as stable. As a measure of uncertainty the standard deviation of the area of the parcels that were stable over the whole time frame was calculated (363.9 km^2).

Table 2.4. Summary of parcels changing outline every year

Year	Total number of parcels	Not changed from previous year	Changed from previous year	Changes the following year	Split the following year	Merged from the previous year	New parcel	Removed the following year
2000	785,407	0	0	193	43	0	0	23,044
2001	836,443	730,871	200	10,274	3081	23	74,037	28,748
2002	853,201	764,451	11,932	23,159	11,538	927	42,315	18,746
2003	895,718	752,337	36,115	17,824	8461	1325	46,015	58,067
2004	889,499	794,967	27,294	3137	1416	1350	41,055	28,255
2005	963,062	829,006	4213	15,956	7394	421	100,205	23,152
2006	984,135	876,423	24,608	32,116	15,756	1252	33,791	22,594
2007	1,020,335	872,854	48,537	43,280	14,779	2895	38,778	24,303
2008	1,048,679	875,777	49,741	65,662	32,153	5622	39,783	22,704
2009	1,117,833	846,069	94,624	104,327	42,024	6173	53,201	38,559
2010	1,192,561	914,679	149,510	57,274	17,317	6783	58,073	30,025
2011	1,231,529	1,039,342	75,891	25,156	5291	3084	46,850	54,408
2012	1,204,018	1,151,835	29,415	0	0	1260	21,508	0

3 Land Parcel Identification System Adaption

To overcome the limitations described in the previous section, a workflow was developed to best adapt LPIS for LULUC assessment with regard to the national GHG inventory. The workflow comprises simple geographic information system (GIS)-based operations as well as purpose-built tools (Figure 3.1).

Below, each step in the workflow is described, including the rationale for the applied operation. The specific functions of the purpose-built tools are described in Chapter 4. A manual for the tools is available as a separate document (see https://github.com/JRGZ/2012-CCRP-FS.9).

1. *Removal of large administrative parcels*. It is recommended that this operation is carried out manually using optical identification. As the administrative parcels generally encompass island groups, they can be easily identified. Overlaying LPIS with digital imagery, such as the freely available ESRI World Imagery series, further simplifies the identification of such parcels. Although an area threshold can be used to remove all parcels above a given area, there is the danger of removing parcels of rough upland grazing from the datasets, as these can be very large.

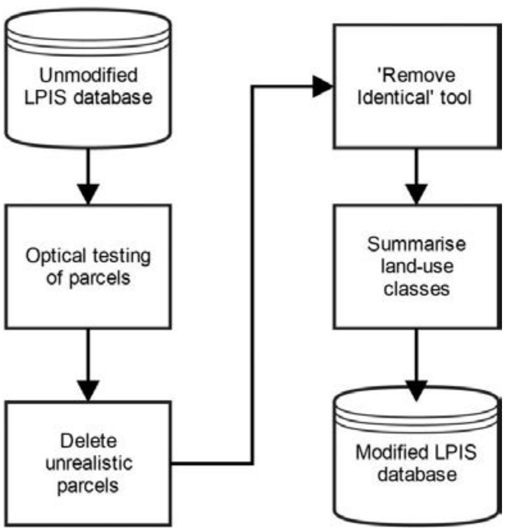


Figure 3.1. Step-by-step description of the steps applied to modify LPIS for use in GHG assessment.

2. *Subdividing LPIS datasets into subsets*. It is recommended that the SplitLayerByAttribute tool (created by Dan Patterson; available for free at http://arcscripts.esri.com/details.asp?dbid=14127) is used to split the national datasets into subsets. To create a splitting attribute it is recommended that the "spatial join" option within ArcGIS is used to join a target layer (any shapefile containing the regions required for the division) with LPIS. Although ArcGIS also provides a function to directly split a dataset, this is not recommended, as this will split parcels that coincide with the boundaries of the target layer. Splitting the LPIS datasets is required as most standard issue office computers do not have the computing power to carry out operations on the full national datasets.
3. *Removing duplicates*. Duplicates can be removed either using the PARCEL_ID provided in LPIS or using the geometry information in the shapefile. It is recommended that both methods are used on each file as each of the methods misses a number of duplications. As duplication is generally linked to commonage, duplicates are assumed to have the same land use.
4. *Summarising land use descriptions*. Depending on the requirements of the dataset, land use descriptions (CROP_DESC) can be summarised in overarching classes. A tool was developed that adds a new field to each shapefile containing a customised land use class.
5. *Adding a unique parcel ID*. A specific tool was developed to add a unique ID for each parcel. The tool assigns a unique numerical ID to each parcel and keeps it static as long as it remains unchanged, as defined by a specific set of criteria (area change of 0.5 ha and centroid distance of 12 m). If a parcel changes outline beyond the given criteria, a new ID is assigned and the previous ID is noted in an additional field.

4 Tool Development

As described in the previous chapter a number of tools were developed to assist with adaptation of LPIS for GHG-related LULUC assessment. This chapter provides a technical description of these tools. All tools were written in Python for ArcGIS 10.1.

4.1 Creating Summary Land Use Classes

The tool reads the CROP_DESC field for each parcel for a given LPIS shapefile, compares the crop description with a user-defined classification and adds an overarching class as a new field to the given shapefile. If multiple crop descriptions are present that fall under different classes, multiple classes will be added, as well as an indicator in a separate field.

4.2 Identify/Remove Duplicates

Duplicates can be identified/removed with the internal ArcGIS tools “Find Identical” and “Delete Identical”. The tools can be used to identify duplicates using either the PARCEL_ID field or the default geographic information field (i.e. “shape”). It is recommended that both methods are used as some identical parcels may have different IDs, whereas using the field “shape” as a criterion has been shown to occasionally miss duplicated parcels.

4.3 Add a Unique Identifier

Adding a new unique ID that stays constant through time if a parcel stays constant according to given criteria is carried out in three steps:

1. In the initial step two iteration loops are carried out. The first loop iterates through each year of a LPIS timeline. Within each iteration, the second loop iterates through all years subsequent to the initial year. For the first step of each iteration the tool adds a new field with a numerical ID to the initial shapefile. Both the initial and the subsequent year are then converted into point shapefiles, representing the centroid of each parcel. The point files are then overlaid using an ArcGIS spatial join operation based on distance. The step creates a temporary joint file in which each centroid of the initial year has the attributes of the closest centroid of the subsequent year assigned; in addition, the operation automatically adds a field containing the distance between the centroids. To assess which parcels are considered constant over time, the area difference and the centroid distance are compared against set criteria (maximum area difference and maximum centroid distance). Parcels not meeting the criteria are then removed from the joint file. For the remaining parcels, the unique ID added previously to the initial year is assigned to the corresponding parcel in the subsequent year. These are then flagged “accounted for” and in the next step the first iteration of the numerical ID will be added only to parcels not flagged.

2. The next step adds the initial description field “Comment” to distinguish between “unchanged” and “changed” parcels. The tool compares the unique IDs between subsequent years. If IDs in the initial year are not present in the subsequent year, or vice versa, the parcel will be flagged as “Parcel removed next year” or “Added parcel”, respectively. If the ID is present in both years the parcel will be flagged as “unchanged”.

3. The final step adds details to changing parcels. Comparing two consecutive years, the script uses the geometry of parcels not flagged as “unchanged” to assess if the centroids of parcels flagged as “Added parcel” fall within the outline of any parcel in the previous year and vice versa if the centroids of parcels marked as “Removed next year” fall within the outlines of parcels in the subsequent year. If either is the case, parcels will be reflagged as “changes outline” (initial year) and “changed outline”. In order to enable the tracking of parcels through time, two new fields are added to each LPIS dataset:

   (a) “OldIDs” contains the previous ID(s) in case a parcel changed outline;

   (b) “NewIDs” contains the subsequent ID(s) in case a parcel will change outline.

The tool reports successive changes, such as newly added parcels being removed the following year.

4.4 Add Identifier History

The "Add unique identifier" tool adds information about the immediate previous/subsequent parcel if a specific parcel is subject to an outline change. However, the tool does not create a full list of the whole available timeline of the LPIS data. This tool was developed to create a full history of each parcel based on location. It creates a new field containing all IDs that have occurred at the given location.

4.5 Additional Tools

Two additional tools were created for specific timeline analyses of single or multiple parcels. The general aim of the tools is to create polygons that contain full timelines for each location within LPIS. Furthermore, a tool to combine LPIS data with forest cover information from the IFORIS database and land cover information from CORINE was developed.

4.5.1 Extract given field value

This tool extracts all parcels that have shown a user-defined field value in a given field during a given timeline, e.g. parcels that have been cropland. The tool creates a copy of all LPIS datasets selected. In the next step the tool checks all parcels if the selected value is present in the specified field and, if that is the case, adds the current ID and all IDs present in the ID history to a new list. In the final step the tool iterates through the copied LPIS datasets and removes all parcels if their ID is not in the list.

4.5.2 Summarise field history

This tool creates a new shapefile containing the history of a given field over a predefined timeline at a specific location as reported in LPIS. The tool copies the first dataset from the predefined timeline and removes all fields except for the given field and the unique ID and ID history, as well as the geographic information. This copy acts as a template for the field history. For each subsequent year the information from the given field is added based on the ID. If the ID of a following year is not present in the template a new feature will be added to the template. Because of changing outlines, the same location may be represented by different overlapping parcels with different IDs. As a result, the finished summary requires a "dissolve" function. However, as the provided function in ArcGIS gives limited control over how field entries are summarised in the dissolve output, a separate function was developed and is applied as part of the tool.

The function carries out a "union" on the summary shapefile. This creates a new shapefile containing the minimum overlapping polygons (Figure 4.1). In the case of an outline change, overlapping and non-overlapping parts of polygons will be broken up into separate new parcels. Furthermore, overlaps will lead to multiple parcels of identical geometry containing the information of the different original parcels (see Figure 4.1). For those parcels the tool will combine the field values so that all identical parcels show the full available field record. In the final step, the "remove identical" tool in ArcGIS is used to remove all duplicate parcels. As the information is summarised for all parcels, no information is lost in this step.

As the "union" operation leads to a large number of very small parcels because of small overlaps, the tool removes all parcels smaller than 0.1 ha. These parcels represent less than 1% of the overall area but about 50% of the total number of parcels after the "union".

4.5.3 Filling the gaps in LPIS

A script has been developed to carry out integration of LPIS with the CORINE and forestry datasets. The script uses official forestry datasets as the main source of forestry information and fills gaps within the LPIS datasets using CORINE land cover data from 2006. The map combining all information is structured hierarchically, with information from the forestry datasets being of the highest order, followed by information from LPIS and, lastly, CORINE information. Because of the different resolutions between the CORINE and the other datasets, as well as the lack of temporally explicit information within CORINE, land use change to and from CORINE from and to IFORIS or LPIS is generally tagged as to or from "other". Although the land use given at a specific location is based on the hierarchy of the input, all input information is maintained in the dataset.

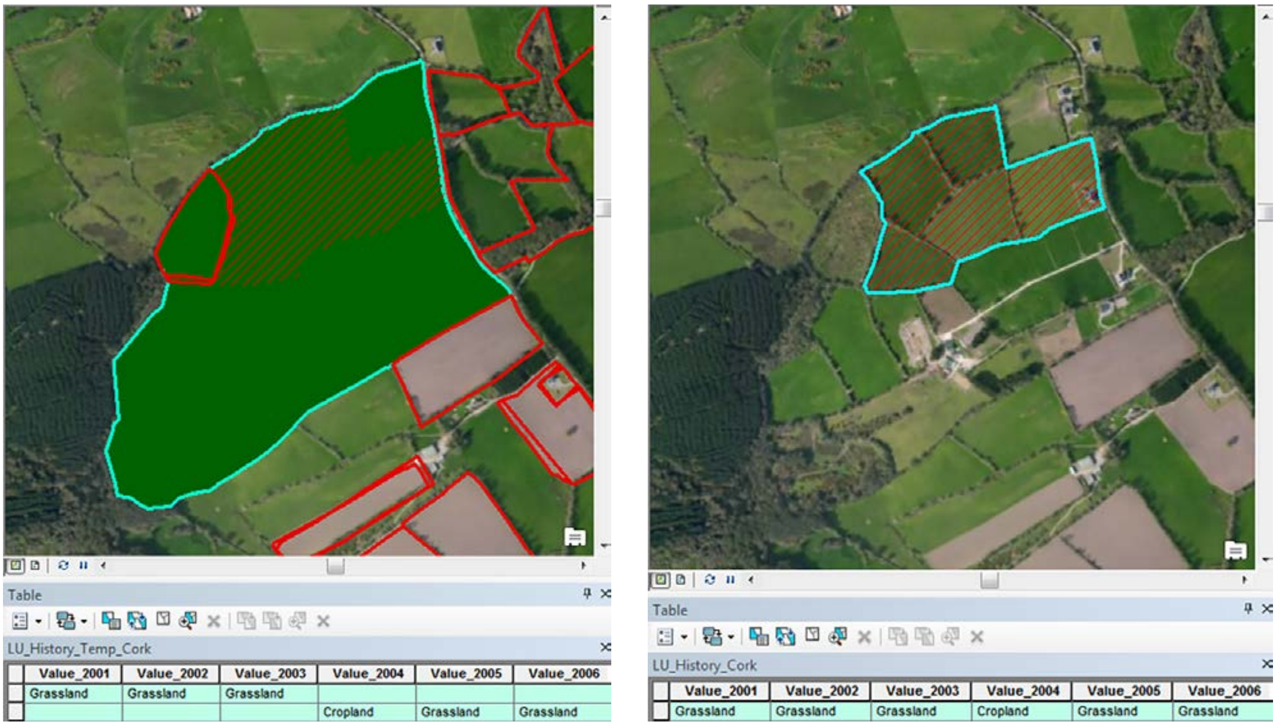


Figure 4.1. Dissolving parcels using the “summarise field history” tool. Background image source: Esri, Microsoft (UC-G) image captured on 29 March 2012, as shown in the 20 February 2014 version of the World Imagery map.

5 Examples of Using LPIS

A number of additional tasks were carried out during the project, showing the usefulness of LPIS. This chapter summarises a number of the minor tasks, whereas Chapter 6 provides a detailed description of the review of crop residue burning using LPIS and Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data.

5.1 Initial Assessment of Arable Farming on Peatland

The spatially explicit land use data provided by LPIS allowed for the identification of sites where arable crops are potentially grown on peat soils, a practice that could potentially lead to high CO_2 emissions. Possible sites were identified by overlaying the LPIS data with a soil map and the Office of Public Works (OPW) arterial drainage map. The soil map provided information on the extent of peat soils, whereas the arterial drainage network allowed narrowing of potential sites, as drainage is crucial for growing arable crops on organic soils. Using this approach, 325 potential sites were identified. Because of the low resolution of the soil map, it was necessary to use remote sensing (Bing Maps – Microsoft, Albuquerque, NM, USA; aerial photography) to classify the likelihood of the potential sites being situated on peat soils. Three classes (high, medium, low) were assigned based on the proximity of the sites to distinct bogs. Of the 325 sites, 65 showed a high potential for cropping on peat soils, 162 showed a medium potential and 90 showed a low potential. For the remaining eight sites, no sufficient aerial imagery was available for assessment. The results were further investigated in the follow-up project by Donlan *et al*. (2019).

5.2 Assessing Cropland Dynamics

Cropland dynamics have a potential impact on GHG accounting. Reporting guidelines recommend reporting temporary grassland as cropland. Although temporary grassland is not defined in the guidelines, current reporting within the EU follows the CAP definition, counting any land under grassland for no longer than 5 years as temporary.

Identifying temporary grassland can be challenging as it is currently not comprehensively reported as such (e.g. as fallow/setaside). Even within LPIS, temporary grasslands are currently not reported.

Using the tool for extracting parcels containing specific field values and the tool for creating field value timelines, land use histories of all lands being reported as cropland during a 12-year history were created. The output is a shapefile in which each polygon contains the complete land use history at the given location.

The resulting dataset allows for a more in-depth analysis of the crop rotation patterns of arable land, as well as analysis of the patterns in parcels permanently entering or exiting arable agriculture. Using the data, three approaches to cropland reporting were compared:

1. total annual land use areas (comparable to data provided by the CSO);
2. direct comparison of two years using high spatial resolution data (LPIS);
3. assessing land use using LPIS-derived land use history to distinguish between permanent and temporary grassland.

The results suggest a much more dynamic cropland area than initially assumed when just observing land use in single years. In general, the area being reported as cropland in at least one year was significantly larger (7373.4 km^2) than the area reported as cropland each year (3752.3 ± 542.3 km^2; 50.9% ± 7.4% of the total area), indicating that, although the total annual area of cropland remains relatively static, there are constant land use transitions between cropland and non-cropland.

5.3 Rasterising LPIS

Currently, LPIS is available as polygon shapefiles. Although polygon shapefiles provide high levels of accuracy, they require substantial computing power, especially when using multi-temporal high-resolution data such as LPIS. In order to process the data more efficiently, it may be of benefit to convert the data to raster format.

Raster datasets produce a continuous surface and therefore provide a number of benefits: (1) lower computing power requirements when working at large scales (county or national scale), (2) no overlapping of parcels and (3) less ambiguous outlines when looking at land use change over time. As occasional parcels change outline over time, criteria to separate corrections within the database and real land use change were introduced (see Chapter 4). When using a raster approach each cell represents a distinct location and land use change will be calculated for the cell, independently of underlying changes in the parcel outline.

The disadvantages of this approach are the loss of accuracy by representing a distinct outline by a number of square cells. In order to assess the error introduced by raster conversion, a 10-km vector grid was utilised. Within each vector grid cell the areas for five land use classes (cropland, forestry, grassland, other, multiple) were summarised both based on the original vector-based LPIS data and for a range of converted rasters of different resolutions (10 m, 25 m, 50 m, 100 m, 250 m, 500 m, 1000 m). For the raster of each resolution, the absolute and relative (based on the average area of the land use in all cells) difference between the vector-based and raster-based areas was calculated.

The initial results show that the error caused by rasterisation is highly dependent on the land use observed and that further analysis is required.

6 A Review of Crop Residue Burning: MODIS Fire Detection Archive for Ireland

6.1 Introduction

Crop residue burning is the practice of setting fire to post-harvest residues, consisting of stubble and plant litter, directly on the field. It is practised worldwide as a cost-efficient way to remove excess plant residues, to increase the growth rates of crops by reducing shading in the early stages of plant growth and to provide short-term fertilisation using the ash.

However, crop residue burning is recognised as a source of GHG emissions. It is considered to produce a significant amount of non-CO_2 GHG emissions, mainly N_2O and CH_4 (IPCC, 2006). The Food and Agriculture Organization of the United Nations reported GHG emissions as a result of crop burning of 21,511.16 Gg CO_2eq worldwide in 2010; the amount reported for Europe in the same year was 2486.73 Gg CO_2eq (FAO, 2013). As emissions from crop residue burning are a significant part of the global GHG budget, they are part of the *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006) and should be reported on a regular basis.

In Ireland, the practice is discouraged and is not common; however, it is not illegal and it has been suggested that burning may occur as an isolated practice. The aim of this study was to assess the available data with regard to reporting on crop residue burning activity and to identify possible instances of this activity occurring.

The ecosystem most vulnerable to the outbreak of fire is degraded peatland, where the water table has been significantly altered by historical and ongoing drainage. In addition, heath and moorland habitats can be managed with controlled fire to control invasive growth.

6.2 Materials and Methods

Active fire data from 2001 to 2011 were acquired from National Aeronautics and Space Administration (NASA) earth data (https://earthdata.nasa.gov/data/near-real-time-data/firms/active-fire-data). The data were provided as point shapefiles based on MODIS imagery by the Land, Atmosphere Near real-time Capability for EOS (LANCE) Fire Information for Resource Management System (FIRMS). The points represent the centroids of 1 km × 1 km pixels in which one or many fires have been detected. Fires were detected using a special algorithm to scan each pixel in the MODIS imagery for strong emissions in the near infrared linked to active fires (Giglio *et al*., 2003).

To assess the probability of crop residue burning, the active fire data were overlaid with CORINE land cover data (2000) and spatially and temporally explicit land use data (LIPIS; spatial unit: land parcel; temporal unit: year).

As the exact point of a fire represented the centroid of a 1 km × 1 km square, a buffer (radius 500 m) was created around each point. The buffer was then overlaid with the respective LPIS data for the year of the fire, as well as with the CORINE land cover data. The area of each land use within the buffer was summarised and buffers containing croplands were identified.

The probability of a fire being a peat fire was assessed using aerial photography available on Bing Maps. This was necessary because LPIS is a database of agricultural land use and information on peatland is generally not included. To identify peatland fires, a three-tier probability level (high, medium, low) of peat fires was assigned based on the proximity of a point to a recognisable area of peat cutting or bog. The levels were defined as follows:

1. high: recognisable peat within the buffer;
2. medium: recognisable peat in close proximity to the buffer;
3. low: no peat in the vicinity of the buffer.

Based on a collection of intermediate quantities of the fire detection algorithm, each fire point was assigned a confidence value (0–100%), which can be subdivided into three classes (low confidence fire, nominal confidence fire and high confidence fire) (NASA EOSDIS, 2013).

6.3 Results

In total, 602 active fire points were detected in the years 2001–2011 (2003 was excluded as no land parcel information was available at the time of writing) (Figure 6.1). Of the total number of fire records, 42 were removed during the overlay as no parcel information was available within the 500-m radius, indicating a very low probability of significant agricultural activity. Of the remaining 560 active fire points, 518 were classified as nominal or high confidence fires and 42 were classified as low confidence fires. The majority of the 560 active fire points recorded (*n* = 552) had grassland within the 500-m radius, with 486 sites showing 80% or more grassland coverage within a 500-m radius.

The analysis identified 21 potential sites for crop residue burning (Table 6.1), with crop activity within a 500-m radius of a high or nominal confidence fire. Twelve of these potential sites were shown to have peat cutting within a 500-m radius and were assigned a high probability of being a peat fire (Figure 6.2a); one was assigned a medium probability of being a peat fire, with peat cutting being adjacent to the 500-m radius (Figure 6.2b), and eight had no peat cutting in their vicinity.

The results of the overlay with the CORINE land cover data are shown in Table 6.2. When overlaying the active fire records with CORINE land cover data, 25 points showed arable land within the 500-m radius. However, only 12 of these points were identical to the results from the overlay with LPIS. In addition, the number of fires with a low peat fire likelihood was higher (*n* = 12).

6.4 Discussion

Generally, there is very limited evidence that burning of crop residue is common practice in Ireland. As shown in Table 6.1, only eight active fire points within the observed time period that show cropland within a 500-m radius cannot be attributed to peat fires,

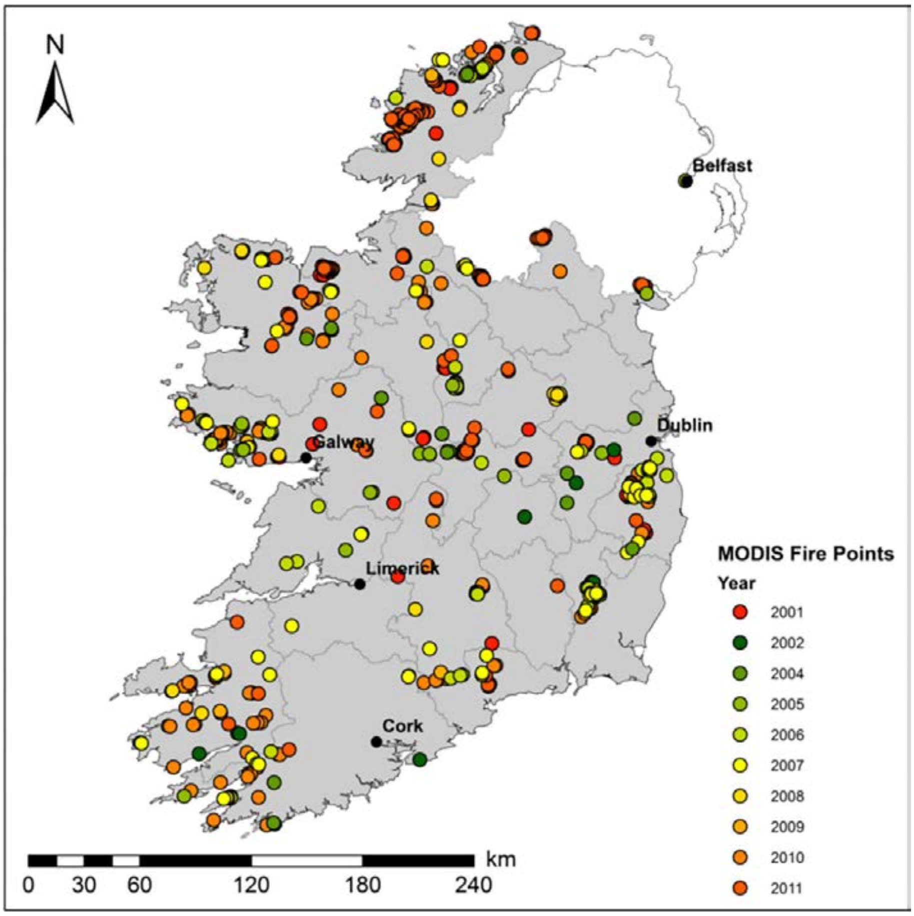


Figure 6.1. Location and year of occurrence of all fires recorded in Ireland. All data taken from the NASA LANCE FIRMS database.

Table 6.1. General information and proportion of different land uses (% of total area) within a 500-m radius around MODIS active fire records that show cropland within the radius

General information						Land use in 500-m radius, % of total area (based on LPIS data)							
Fire ID	Latitude	Longitude	Acquisition date	Confidence[a]	Peat fire	Cereals	Grassland	Forestry	Root crops	Other crops	Wetland	Settlement	Total
29	52.376	–7.573	19/09/2001	45	Low	52.9	35.7	0.0	8.7	2.8	0.0	0.0	100.0
30	53.266	–6.573	02/11/2001	99	Low	42.0	41.8	2.9	0.0	13.3	0.0	0.0	100.0
114	52.972	–8.041	21/04/2010	42	High	17.9	75.2	0.0	0.0	0.0	5.8	1.1	100.0
173	53.261	–7.314	30/04/2011	96	High	12.0	86.8	1.2	0.0	0.0	0.0	0.0	100.0
196	53.333	–6.817	04/05/2011	42	High	6.2	93.8	0.0	0.0	0.0	0.0	0.0	100.0
211	52.653	–7.049	12/07/2011	62	Low	9.9	87.8	0.0	0.0	0.0	0.0	2.3	100.0
242	53.261	–7.318	01/05/2011	0	High	20.4	77.7	1.4	0.0	0.0	0.0	0.5	100.0
315	55.331	–7.191	01/05/2011	100	High	0.0	98.1	0.0	0.8	0.0	0.0	1.1	100.0
406	53.695	–7.424	01/05/2011	59	High	0.0	83.4	0.0	0.0	15.7	0.0	0.8	100.0
500	53.269	–7.303	03/05/2011	100	High	99.3	0.7	0.0	0.0	0.0	0.0	0.0	100.0
543	53.314	–7.786	02/05/2011	26	Medium	8.0	90.3	0.0	0.0	0.0	0.0	1.7	100.0
556	53.268	–7.300	02/05/2011	66	High	36.5	53.3	10.2	0.0	0.0	0.0	0.0	100.0
722	53.294	–7.792	02/05/2011	88	High	3.0	94.2	0.0	0.0	0.0	2.1	0.6	100.0
736	53.611	–7.863	11/06/2006	82	High	4.2	75.7	19.3	0.0	0.0	0.0	0.8	100.0
818	52.859	–6.397	03/05/2007	77	High	0.0	96.1	0.0	3.9	0.0	0.0	0.0	100.0
835	52.826	–6.445	28/04/2004	100	High	18.3	14.9	66.9	0.0	0.0	0.0	0.0	100.0
854	53.196	–6.959	09/09/2004	47	Low	94.1	5.9	0.0	0.0	0.0	0.0	0.0	100.0
855	53.455	–6.404	09/09/2004	64	Low	77.0	18.7	0.0	0.0	4.3	0.0	0.0	100.0
870	53.305	–6.577	23/09/2002	87	Low	85.4	14.6	0.0	0.0	0.0	0.0	0.0	100.0
871	53.149	–6.887	23/09/2002	53	Low	29.5	69.1	0.0	0.0	0.0	0.0	1.3	100.0
872	51.814	–8.141	25/09/2002	75	Low	77.9	12.7	0.0	8.6	0.8	0.0	0.0	100.0

[a]The confidence field describes the detection confidence as assigned by NASA (see https://earthdata.nasa.gov/faq/firms-faq#ed-user-guides for details – accessed 7 February 2020).

Figure 6.2. Example of a fire record being assigned (a) a high probability of being a peat fire and (b) a medium probability of being a peat fire. Peat cutting can be recognised by the dark brown colour and the characteristic linear features. Background image sources: (a) Esri, DigitalGlobe image captured on 17 June 2014, as shown in the 30 October 2019 version of the World Imagery map; (b) Esri, DigitalGlobe (WV02) image captured on 24 March 2017, as shown in the 30 October 2019 version of the World Imagery map.

which are common in Ireland and can be associated with peat cutting and controlled burning of vegetative cover on blanket bog to promote heather growth (Irish Peatland Conservation Council, 2013). Of the eight sites that cannot be associated with peat fires, only four sites had > 50% cropland within the 500-m radius. Although it cannot be ruled out that crop residue burning was practised in these cases, it is also possible that these fires had other natural or anthropogenic origins. In two of the cases more than one fire occurred within the time frame of a few hours at distinct, separate spatial locations, suggesting that the fires had natural origins, such as dry weather conditions and lightning strikes. Furthermore, there is no interannual repetition of fires at similar locations, indicating that, even if single instances of crop residue burning have occurred, it is not a regular practice.

Generally, the high confidence value of the detected fires allows the assumption that false positives (the detection of fires that did not occur) are highly unlikely. However, there is no indication of the likelihood of fires not being detected, resulting in the possibility of underestimating the amount of fires that occurred in the examined time frame.

Although the overlay with the CORINE land cover data showed a higher number of potential crop residue burning sites, the data are not temporally explicit; therefore, no information on land use in the years of the fires is available. In addition, the spatial resolution of the CORINE land cover data is significantly lower (25 ha). Therefore, the results of the overlay of active fire data with CORINE data are subject to very high uncertainty and the spatially and temporally more precise LPIS data are preferred when assessing the land use/land cover in proximity to active fire sites.

It is concluded that, although single events of crop residue burning cannot be ruled out, it is not common practice in Ireland. Generally, reporting on crop residue burning as part of the national GHG budget is not feasible, as the available data do not allow a distinction to be made between natural and other anthropogenic causes of fire. Furthermore, as the spatial resolution of the fire detection algorithm is 1 km^2, fire cannot be associated with a distinct land parcel. Considering these limitations, any estimate of GHG emissions caused by this activity would show high uncertainties.

Table 6.2. General information and proportion of different land uses (% of total area) within a 500-m radius around MODIS active fire records that show cropland within the radius

General information						Land use[a] in 500-m radius, % of total area (based on CORINE Land cover 2000)											
Fire ID	Latitude	Longitude	Acquisition date	Confidence	Peat fire	112	211	231	242	243	311	312	321	322	324	412	Total
22	53.410	–7.266	13/05/2001	78	High	0.0	0.1	27.4	0.0	0.0	0.0	0.0	0.0	0.0	72.5	0.0	100.0
29	52.376	–7.573	19/09/2001	45	Low	0.0	50.3	49.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
30	53.266	–6.573	02/11/2001	99	Low	0.0	60.4	39.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
33	52.669	–6.777	29/03/2002	81	High	0.0	0.2	48.9	0.0	0.0	0.0	44.33	0.0	0.0	0.0	6.6	100.0
77	53.299	–6.866	12/04/2010	32	High	0.0	11.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.4	100.0
114	52.972	–8.041	21/04/2010	42	High	0.0	18.0	60.4	0.0	0.0	0.0	0.0	0.0	0.0	21.6	0.0	100.0
134	53.603	–8.807	19/04/2010	85	High	0.0	14.5	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.6	100.0
211	52.653	–7.049	12/07/2011	62	Low	0.0	34.7	65.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
242	53.261	–7.318	01/05/2011	0	High	0.0	6.7	12.66	0.0	0.0	0.0	0.0	0.0	0.0	12.88	68.00	100.0
406	53.269	–7.303	03/05/2011	100	High	0.0	6.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.2	100.0
543	53.268	–7.300	02/05/2011	66	High	0.0	5.7	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.9	100.0
736	53.176	–6.156	25/07/2006	45	Low	0.0	2.8	23.5	1.8	45.88	0.0	0.0	0.0	0.0	0.0	26.1	100.0
831	52.049	–8.427	26/09/2003	94	Low	0.0	94.4	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
832	52.047	–8.413	26/09/2003	95	Low	0.0	66.6	7.2	0.0	0.0	26.1	0.0	0.0	0.0	0.0	0.0	100.0
854	53.196	–6.959	09/09/2004	47	Low	0.0	96.2	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
855	53.455	–6.404	09/09/2004	64	Low	0.0	84.1	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
869	53.291	–6.676	26/06/2005	56	Low	0.1	34.6	65.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
870	53.305	–6.577	23/09/2002	87	Low	0.0	85.1	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
872	51.814	–8.141	25/09/2002	75	Low	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
880	53.070	–7.858	18/03/2003	61	Low	0.0	41.5	58.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
903	53.482	–8.385	08/04/2003	0	High	0.0	5.3	39.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.6	100.0
927	55.099	–7.455	17/04/2003	58	High	0.0	38.6	0.4	0.0	0.0	0.0	0.0	12.44	48.66	0.0	0.0	100.0
983	53.532	–8.933	19/04/2003	87	High	0.0	2.9	25.9	0.0	13.6	0.0	0.0	0.0	0.0	0.0	57.6	100.0
984	53.530	–8.918	19/04/2003	99	High	0.0	58.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.7	100.0
993	53.272	–7.304	19/04/2003	35	High	0.0	24.9	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.1	100.0

[a]Land uses are shown as CORINE codes – 112: discontinuous urban fabric; 211: non-irrigated arable land; 231: pastures; 242: complex cultivation patterns; 243: land principally occupied by agriculture with areas of natural vegetation; 311: board-leaved forest; 312: coniferous forest; 321: natural forest; 322: moors and heath; 324: transitional woodland scrub; 412: peat bogs).

7 Conclusions

In conclusion, LPIS has great potential for supporting the LULUC section in the national inventory reporting process. The high spatial and temporal accuracy allow for a much better understanding of Irish agricultural processes at local and macro scales, and the potential of LPIS to be used in conjunction with ancillary data allows for a much better assessment of local conditions of specific land use types.

However, LPIS is subject to a number of limitations because of its original purpose as a single farm payment support tool. The main limitations are the ambiguous grassland classification, incomplete data on forestry and housing, the duplication of parcels to represent commonage, large parcels representing administrative boundaries and changing parcel outlines, as well as non-traceable parcel IDs.

Using ArcGIS 10.1 built-in tools, as well as purpose-built script tools, the suitability of LPIS for assessing LULUC can be significantly improved. However, specific issues, especially the ambiguous grassland classification, require further research and the inclusion of additional data, such as remote sensing information and other sources of suitable activity data.

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Abbreviations

CAP	Common Agricultural Policy
CSO	Central Statistics Office
EU	European Union
FIRMS	Fire Information for Resource Management System
GHG	Greenhouse gas
ID	Identifier
IFORIS	Integrated Forest Information System
LANCE	Land, Atmosphere Near real-time Capability for EOS
LPIS	Land Parcel Identification System
LULUC	Land use and land use change
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
OSi	Ordinance Survey of Ireland
UNFCCC	United Nations Framework Convention on Climate Change

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:

- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

EPA Research Report 309

Evaluating the Suitability of the Land Parcel Identification System for Assessing Land Use and Land Use Change-Related Greenhouse Gas Emissions

Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

Authors: Jesko Zimmermann and Jane Stout

Land use and land use change are important drivers in national greenhouse gas dynamics and therefore are integral to Ireland's greenhouse gas reporting efforts. Spatially explicit data on land use and land use change, however, are sparse, limiting the understanding of the extent of land use change and the capacity to understand the context of land use with regard to other important environmental factors, such as climate and soil.

The Land Parcel Identification System (LPIS), a high spatial and temporal resolution database developed as part of the European Union Common Agricultural Policy to assist farmers and authorities with agricultural subsidies, potentially provides a wealth of data on land use and land use change in Irish agriculture.

As the LPIS was not designed for the needs of national greenhouse gas reporting, its potential strengths and limitations needed to be assessed.

The study demonstrated that, in general, reporting on arable crops showed both a high spatial and a high thematic resolution. With regard to grasslands, however, thematic accuracy was limited as different grassland categories were exchangeable (e.g. "grass" and "permanent grassland"). In addition, although more detailed categories existed (e.g. "rough grazing"), these were not always reported. Similarly, forestry was reported in the LPIS but reporting was not comprehensive.

Identifying Pressures

An in-depth analysis of the LPIS data showed regular changes between croplands and grasslands. This suggests that croplands are much more dynamic than previously assumed. This is highly relevant to greenhouse gas reporting as temporary grasslands should, under regulations, be considered as croplands.

Informing Policy

Research findings have been published in peer-reviewed journals and at conferences. The research was carried out in close conjunction with the Environmental Protection Agency (EPA) greenhouse gas reporting staff and results from the project have directly fed into land use and land use change methodology.

Developing Solutions

A set of ArcGIS tools was developed to pre-process the raw LPIS data received by the EPA. Furthermore, tools to account for land use change over time were created. The tools are currently being used in land use and land use change reporting efforts.

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