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INTEROPERABILITY PILOT PROJECT OF LANDSCAPE FEATURES

Report Information

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1. INTRODUCTION

Agricultural **landscape features (LF)** are considered as small fragments of non-productive natural or semi-natural vegetation in agricultural landscapes which provide ecosystem services and support for biodiversity.

In the current CAP legislation, landscape features (LF) are laid down in Regulation (EU) No 1306/2013 on the financing, management and monitoring of the CAP, that regulates the "cross-compliance system", as elements whose maintenance must be protected by cross-compliance (according to Article 93 and Annex II of that Regulation), in which case they will be considered as eligible areas for receiving CAP funds (according to Article 9 (2) of Delegated Regulation (EU) No 640/2014 supplementing Regulation (EC) No 1306/2013). In other words, under this conditionality, Member States must impose penalties on farmers for non-compliance with the basic standards for sustainable agriculture.

The cross-compliance rules in Annex II include GAEC (good agricultural and environmental condition of land) number 7, which relates to "the landscape and its minimum level of maintenance" and for which **landscape features** are required, including, where appropriate, *hedges, ponds, ditches and trees in line, in group or isolated, field margins and terraces, including a ban on cutting hedges and trees during the bird breeding and rearing season* and, optionally, *measures to prevent invasive plant species*. Notwithstanding this non-exhaustive list of landscapes to be retained, it was left to the Member States to define which landscapes shall be considered as part of the requirement.

Within this framework of Regulation 1306/2013, Article 70 (2) establishes the need to create a reference layer **in the Land Parcel Identification System (LPIS**) to accommodate **ecological focus areas (EFA)**. Member States should therefore be able to take into account the specific information that may be required from farmers in relation to their determination of LFs or other areas potentially qualifying as EFA and, where appropriate, the extent of those characteristics and of other areas which should be considered stable over time.

However, Article 46 (2) of Regulation 1307/2013, establishing rules for direct payments to farmers under CAP support schemes, provides the possibility for Member States to consider landscape features among ecological focus areas (EFA) on the agricultural area to count among agricultural practices beneficial for the climate and the environment. Annex IX of this Regulation, in the paragraph (5) of the equivalent practices to be considered valid as EFA, also sets a non-exhaustive list of **landscape features** (*trees, hedgerows, riparian woody vegetation, stone walls (terraces), ditches, ponds)* to be managed as a possible equivalent practice. But it is Article 45 of Delegated Regulation (EU) No 639/2014, which supplements Regulation 1307/2013, which clarifies the criteria to be applied to this type of EFA by listing the landscape features that can be counted as EFA, clarifying the link with the features protected in the Member States under cross-compliance, as well as establishing a minimum or maximum size for some elements to facilitate their identification and help to ensure that the area is predominantly agricultural. Among the possible types of LF to be selected as EFA includes, together with those protected by conditionality: *hedges or wooded strips; trees (isolated, in line), field copses (including trees, bushes or stones); ponds (excluding concrete or plastic reservoirs); ditches (including open water courses for irrigation or drainage; but not channels with concrete walls); or traditional stone walls*.

Therefore, the current CAP period has been based on the treatment of LFs, based on the above-mentioned cross-compliance of Regulation 1306/2013, as well as an optional treatment based on practices beneficial to the environment (Greening) of Regulation 1307/2013.

In Spain, the LFs are regulated by Royal Decree 1078/2014, which lays down the rules on cross-compliance and, among other things, seeks to ensure effective control of the conservation of LFs and the obligation to maintain them unaltered. Article 2 defines **topographical peculiarities or landscape features** as those features of the land such *as hedges, isolated trees, in line and in groups, field margins, ponds, lagoons, pools and natural watering holes, islands and enclaves of natural vegetation or rock, retention terraces and*, where the Autonomous Community so determines*, heaps, small constructions such as dry stone low walls, ancient pigeons or other traditional architectural features that can serve as shelter for flora and fauna, with the exception of buildings which could pose a health risk to livestock or wild fauna. In this sense, hedgerows are considered to be: dense and uniform alignment of shrubs used for fencing, demarcation or covering areas and land; field margins: a stable strip of land running parallel to the boundary of the agricultural parcel and separating it physically; and retention terraces: drystone terraces, banks covered in herbaceous, shrubby or arboreal vegetation, boundary terraces and ditches in the case of level tillage and the live vegetable barriers perpendicular to the slope that, by controlling runoff, protect the soil from erosion*

Furthermore, by Article 24 (2) of Royal Decree 1075/2014 on the application from 2015 of direct payments to agriculture and livestock farming and other support schemes, as well as on the management and control of direct payments and rural development payments, Spain decided that LFs and other non-productive areas, such as terraces, buffer strips for forest channels and field margins, should not be considered as EFA. Additionally, Article 14 (2) of the same Royal Decree defines as eligible areas the LPIs defined in the Royal Decree on cross-compliance and which form part of the agricultural parcels of the holding.

As part of the work to prepare the LPIS for the new CAP 2015 period, in 2014 Spain launched a pilot study to, where appropriate, identify and monitor EFA in the LPIS database, enabling 3 layers to register LF in the LPIS database. In other words, in order to identify LPIS LF graphically (not only alphanumeric) and to facilitate the possible application of the conversion factors, as provided for in Community regulations, for the subsequent changeover to EFA, the LF geometries are covered in 3 independent layers: polygons; Lines; points. So in Spain the LF are not considered as independent **LPIS reference parcels (RP)** defined in Article 25 (2) of Delegated Regulation 640/2014. Their identification by photo-interpretation and subsequent digitisation does not imply any graphical change in the RP layer.

In 2014, the method was designed and tested based on an automatic process for searching for or detecting LF for certain shapes, dimensions and uses. A number of pilots were conducted in 2015, defining a methodology common to all **autonomous communities (AACC or Regions)** and carrying out this process of searching for areas likely to contain LF. In 2016, as part of the action plan for pastures in Spain, a pilot was launched in 180 municipalities for manual identification by means of photo-interpretation using orthophotos, which made it possible to clarify the methodology by which specific work on the photo-interpretation of LF was started and, where appropriate, subsequent digitisation after analysing which of them was included in the LPIS. Following the pilot study, it was considered that the most appropriate system for this identification was by means of photo-interpretation techniques, using the available LPIS orthophotos and VHR images. The use of LiDAR information was discarded once it was decided not to register scattered trees as LF using this methodology, which is discussed in **point 3.3 of this document**.

This work was reinforced by the fact that, although the EU Regulations do not include the obligation to digitise LPIS in the LPIS, the European Commission, in its audits of accounts clearance procedures, reported that, if these elements are not digitised, it would not be possible to effectively control their preservation. The planned initial identification and digitalisation was completed by the end of 2021.

The coverage of LF is maintained jointly by **FEGA** and the AACC. This work is based on decisions taken collegially at the LPIS Coordination Board, which is set up on a regular basis and of which the **IGN** is also a member. This maintenance work includes the fact that once a specific photo-interpretation has already been carried out in a municipality and with most of its already identified LFs, and so the work will not look for elements but review its situation and update the possible variations in the database (modifications, additions and downloads), each time the orthophoto of that area is renewed, the RP will be updated together with the revision of the LFs, enabling the continuous identification, integration and maintenance of the 3 layers of LF in which to record these elements as points, lines or geometry, depending on the type (trees, field margins, terraces, etc.) and the origin of their digitisation. Therefore, in the work on updating the LPIS due to a change in the orthophoto, before creating a new RP with the criteria for editing the revision work due to the renewal of the orthophoto, it is checked whether, in view of the perception made in the images and their dimensions, it is or not a LF. In addition, this methodology is used for the identification and maintenance of LPIS for the identification and maintenance of LF in the office and by photo-interpretation, with the exception of LF from field checks.

These LPIS LF layers was used to implement phase 3.3 of this work on the direct mapping of Landscape Features by photo-interpretation “Direct mapping LF (photointerpretation)” and thus correctly evaluating the rest of the sources in the later phases provided under.

The possible sources of information to feed the layers of LF are: photo-interpretation work (on the LPIS orthophotos and available VHR images), on-the-spot checks (classical and remote sensing), farmers’ requests for amendments to the LPIS, or cross-compliance checks on the alteration of LPIS, apart from the use of existing data, such as raster cover of vegetation used for the calculation of CAP 2015 (based in turn on LiDAR vegetation information).

Future work in this area will be aimed at carrying out activities to identify LF in mowing meadows, photointerpretation of general LF, improve the identification of LFs in certain regions and agricultural parcels, or examine the possibility of improving the homogenisation and purification of the register of LFs in the methodology.

This work is intended to address the future challenges of CAP reform, which aims to achieve higher environmental and climate objectives, thus strengthening the system applied in the area of cross-compliance, transforming it into what is known as “Reinforced condicionality”, which will also include requirements in relation to GAEC under the Regulation (EU) 2021/2115, including GAEC 8 on the minimum percentage of agricultural area devoted to non-productive areas or features and on the Retention of Landscape Features, which will replace the current

GAEC 7 on LF. With the New Delivery Model concept in the design and management of the future CAP 2023 in mind, the main dares to be considered are:

- Any area of the holding which is covered by **LF** subject to the retention obligation under **GAEC standard 8** listed in Annex III are eligible for the **intervention in the form of direct payments** (Article 4.4b, of Regulation (EU) 2021/2115 establishing rules on support for CAP Strategic Plans).
- The **eco-schemes** to be stablished by MS could cover **LF** or **non-productive areas** (maintenance and creation) for the protection of biodiversity, conservation or maintenance of habitats or species (Article 31.4.e of Regulation 2021/2115).
- For each **Reference Parcel (RP)** Member States shall record in the LPIS: the type and location of **LF** that are stable in time on the parcel relevant for the eligibility of **area-based interventions** and for **conditionality** requirements (Article 2.7.d, of Commission Delegated Regulation (EU) 2022/1172 supplementing Regulation 2021/2115), as attributes or layers; and where applicable, locate and determine the size of the LF under **GAEC standard 8** relevant for the minimum share of agricultural area released to **non-productive areas** or **features** (Article 2.7.e, of the same Commission Delegated Regulation 2022/1172).
- Where relevant, LPIS shall comply with the exchange and integration of data on agricultural instruments in delimited protected zones and designated areas as the LF under the good agricultural and environmental conditions defined in accordance with the condition (Article 66.3 of Regulation 2021/2116)
- The geo-spatial aid application (GSAA) shall contain the type, location and, where relevant, size of **LF** relevant for **conditionality** or **interventions** (Article 8.3.c, of Implementing Act (EU) 2022/1173, laying down rules for the application of Regulation 2021/2116). So, for the different interventions, farmers could declare these LF areas and should know how to do it for each intervention.

Based on the JRC guide “Usability of external datasets for the inventory of landscape features”, our objective was to develop a methodology and a pilot case study for inventory and location of LF to contribute to the improvement of the control of these LF.

The scope of the pilot case study was to assess the usability of existing datasets (IACS and third party datasets) to create a comprehensive dataset of LF **(PILOT LF layer)**. As the concept of LF is strongly connected to agricultural land, as well as the ecological and policy motivation to quantify them, the exercise was restricted to the agricultural area and the areas adjacent to them. In particular, the pilot involved the following tasks:

1. **Data assessment (confirm data sources usefulness for LF). Analysis of semantic definitions and mappings**

2. **Production a LF dataset by automatic integration of available data**

3. **Direct mapping LF (photointerpretation)**

4. **Overlay LF datasets (overlay 2 and 3)**

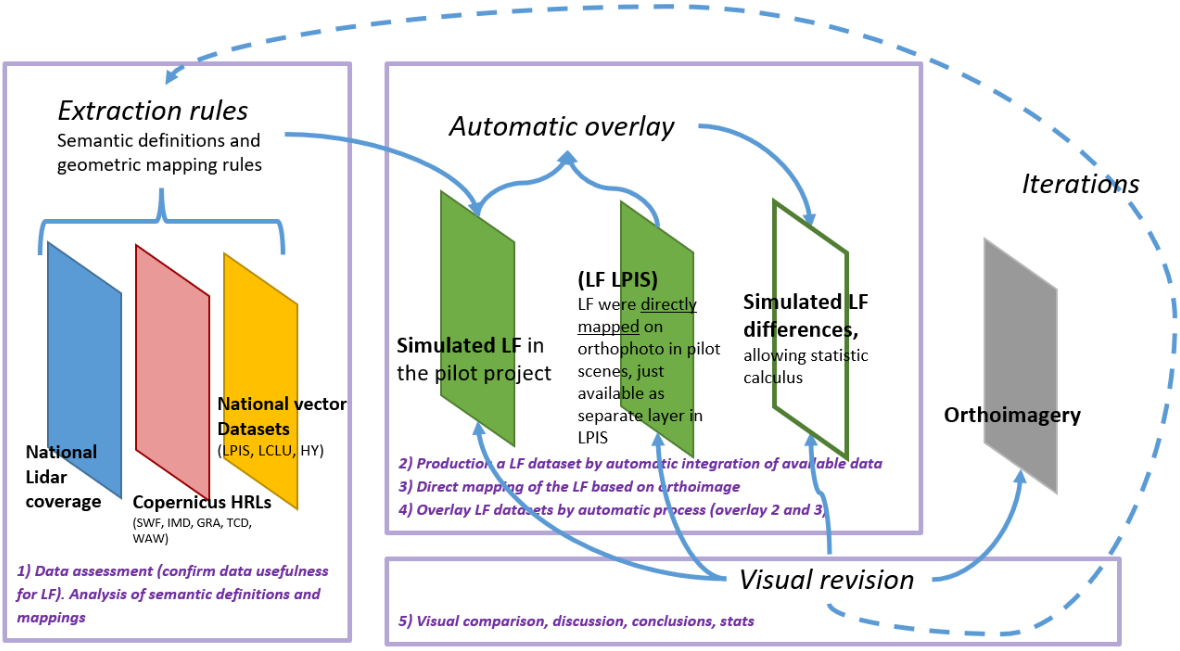
5. **Visual comparison and stats**

6. Discussions and conclusions

7. Report

Within each one of them, a division of tasks was carried out between IGN and FEGA due to this collaborative study.

The following picture show the different phases applied in this project:

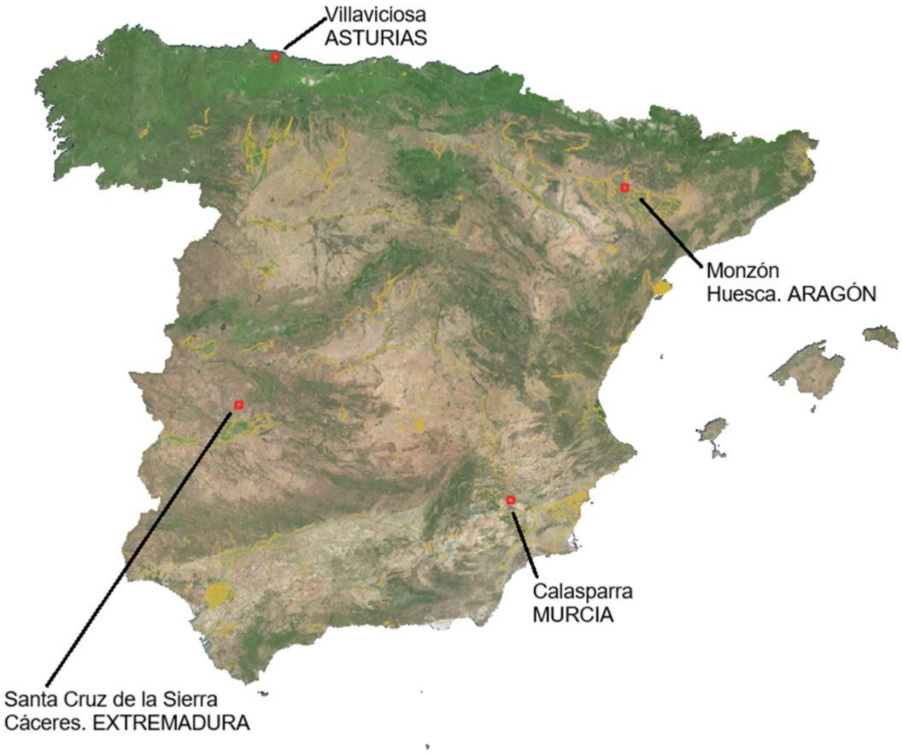


2. TEST AREAS

In order to reach the objective to study an area of 200-300 km^2, it was determined the selection of four work pilot units of 8x8 km^2 in 4 different Spanish regions:

- Monzón (Huesca, Aragón).
- Calasparra (Murcia).
- Villaviciosa (Asturias).
- Santa Cruz de la Sierra (Cáceres, Extremadura).

The selection of these 4 sample areas (8x8 km) was made taking into account: the presence of LF already identified in the LPIS, and different agro-climatic conditions.



Every area was evaluated through photointerpretation with the aim of compare the automatic landscape features generated in the Pilot LF test areas with LPIS features. This task has involved a high workload

3. WORK PHASES

The different phases developed in the pilot study are described below.

3.1. Data assessment (confirm data sources usefulness for LF). Analysis of semantic definitions and mappings

Firstly, before evaluating the information available to carry out the study, it has been agreed how the Landscape Features will be defined. According to the typology, data was analysed taking into account the existence of four expected classes: woody features, grassy features, wet features and stony features. Regarding the information format, the raster format was used in order to achieve greater speed in the processing and data assessment.

The first step in the project was to identify and propose an accessible data sources. Due to the detail level required in the study and, in the case of Spain, the availability of high resolution data was ensured for some topics. It was used as reference the PNOA LiDAR, and other data sources such as HR SIOSE, LPIS and GRI on Hydrography.

3.1.1 Study of national and European information sources

In the following table, the possible **reference sources available** and its possible use have been numbered and evaluated, both by IGN and FEGA.

Available dataset	Coverage	Deliver	Geometry type/format	Valuable for
LUCAS	EU	EuroStat	points	all types
Copernicus HRLs status versions (imperviousness, forest, water&wetness, small woody features)	EU	EEA	pixel	woody, wet, stony
Copernicus HRL continuous parameters (plant phenology)	EU	EEA	pixel	woody, grassy
CLC+ Backbone	EU	EEA	pixel/polygons	all types
LPIS LF (Direct mapping LF (photointerpretation))	Spain	FEGA	polygons/lines	all types
Lidar PNOA	Spain	FEGA/IGN	pixel	woody, grassy, stony
Geospatial Reference Information on Hydrography	Spain	IGN	polygons/lines	wet
High Resolution National Land Cover and Land Use System (HR SIOSE) that includes Cadastre and LPIS	Spain	IGN	polygons	all types

Available dataset	Coverage	Deliver	Geometry type/format	Valuable for
LPIS Reference Parcels (RP)	Spain	FEGA	polygons	all types
Farmers declaration (geometries GSAA)	Spain	FEGA	polygons	all types
National Forest Map (MFE)	Spain	MITERD	polygons	woody, grassy
Survey on Areas and Crop Yields (ESYRCE)	Spain	MAPA	polygons	all types
National Topographic Database (BTN)	Spain	IGN	polygons/lines	stony
Sentinel (CAP monitoring)	Spain	FEGA	pixel	all types
Images from the National Plan for Aerial Orthophotography PNOA (for ortho-photointerpretation)	Spain	FEGA/IGN	pixel	visual comparison
VHR (Deimos 3m XS, 0.5m PAN, marzo-octubre 2021)	Spain	IGN	pixel	visual comparison

For each of these data sources, the following characteristics help to determine which of them were used as input for the study:

- Coverage
- Deliver
- Geometric type
- Scale/resolution
- Last version
- Updateness
- Valuable for functional LF classes
- Impact on results

In addition, this initial assessment served to find which partner (FEGA or IGN) was responsible for studying each of them.

It was proposed that FEGA analysed the viability of the following sources:

- LPIS LF. This data source is available in Spain and it complies with the JRC specifications and comes from direct mapping work of landscape elements by photointerpretation on orthophoto, as well as from the information provided by the regions from field controls (classics on the land and by remote sensing techniques) and modification requests submitted by farmers. For this reason, it was considered the results of the phase 3 of this work, the direct mapping of Landscape Features by photointerpretation. No actual new direct photointerpretation of LF was accomplished in this work.

- LPIS Reference Parcels (RP). It is the reference parcel established by article 2 of Commission Delegated Regulation (EU) No 640/2014, and it is defined as a geographically delimited area retaining a unique identification as registered in the identification system for agricultural parcels referred to in Article 70 of Regulation (EU) No 1306/2013. It was used as a source of information about the selected working pilot areas.

- Farmers declaration (geometries GSAA). Farmers declaration layer of the last available campaign, once completed, existing in the Geospatial Aid Request (GSAA) were analysed as part of the IACS aid requests subsystem, which contains the declarative information of the farmers.

- National Forest Map (MFE). It was evaluated as a possible source of external information from third parties. It was necessary to know if it has detailed information to detect tree patches or other landscape features.

- Survey on Areas and Crop Yields (ESYRCE). It was evaluated as a possible source of external information from third parties

- Sentinel (CAP monitoring). It was evaluated as a possible source of external information from third parties. This assessment was done even knowing that the Sentinel images may not be sufficient to meet the detailed expectations of the landscape features due to their 10 metres resolution.

Regarding the IGN, the following will be analysed:

- ❖ LUCAS: It was evaluated as a possible source of external information from third parties.

- ❖ Copernicus HRLs status versions (imperviousness, forest, water&wetness, small woody features). This information was useful to detect and discard wet, woody, grassy and stony landscape features.

- ❖ LiDAR PNOA. The vegetation and building heights information derived from the LiDAR point clouds were used as source of additional information to detect or discard landscape features.

- ❖ CLC+ Backbone: This information could be useful to detect and discard wet, woody, grassy and stony landscape features.

- ❖ Geospatial Reference Information on Hydrography: It was evaluated as a possible source of external information from third parties. This dataset contains detailed information contributing to detect wet areas or other landscape features.

- VHR (Deimos 3m XS, 0.5m PAN): this information initially considered available for the period of march-october 2021

- PNOA orthophotos (National Plan for Aerial Orthophotography). Orthophotos were an input material used during the project.

Phase one made possible to differentiate the data sources that, for various reasons, were used to discard or detect existing landscape elements.

3.1.2 Information sources used and rejected after their study

The selected data sources to elaborate the pilot study are the following ones:

Used sources:

- **National**: LPIS Reference Parcels (RP), LPIS LF, PNOA LiDAR vegetation and building digital surface models, National Forest Map, High Resolution SIOSE, GRI Hydrography. PNOA Images have been used as reference information to check and analyse the results.

- **Continental** (Copernicus Land Monitoring Service): HRL status versions of Imperviousness, Small Woody Features, Water & Wetness, Grassland, Tree Cover Density.

Rejected sources:

- **National**

  - Farmers Declaration: No references to landscape features, only crops. *However, the identification of **reference parcels with or without declaration** has been considered.
  - National Forest Inventory: Shows sample information as points in forest areas. That is not comparable with the rest of sources.
  - Survey on Areas and Crop Yields (ESYRCE): Sample information as tiles in agricultural land. That is not comparable with the rest of sources.
  - National Topographic Base: No valid or interested elements for the landscape features identification.

- **Continental**

  - LUCAS and transects LUCAS: Sample information non comparable with the rest of sources. Information without geometry, only statistic data.
  - Copernicus HRL continuous parameters (plant phenology): Not used because its incidence or importance in the detection of LFs are unknown, as well as its reliability.
  - Copernicus CLC+ Backbone: Final public data not available.
  - Sentinel 2 images: Do not directly offer LFs identification. Automatic information extraction techniques from image processing were not considered in the pilot study. Insufficient resolution.

- VHR images: Do not directly offer LFs identification. Automatic information extraction techniques from image processing were not considered in the pilot study.

It is important to note that it was not possible to establish a direct connection for all LF target classes, since the definition of the sources does not include all the necessary concepts to reproduce LFs. Also, it was not possible to differentiate subclasses within each LF (woody, stony, grassy y wet).

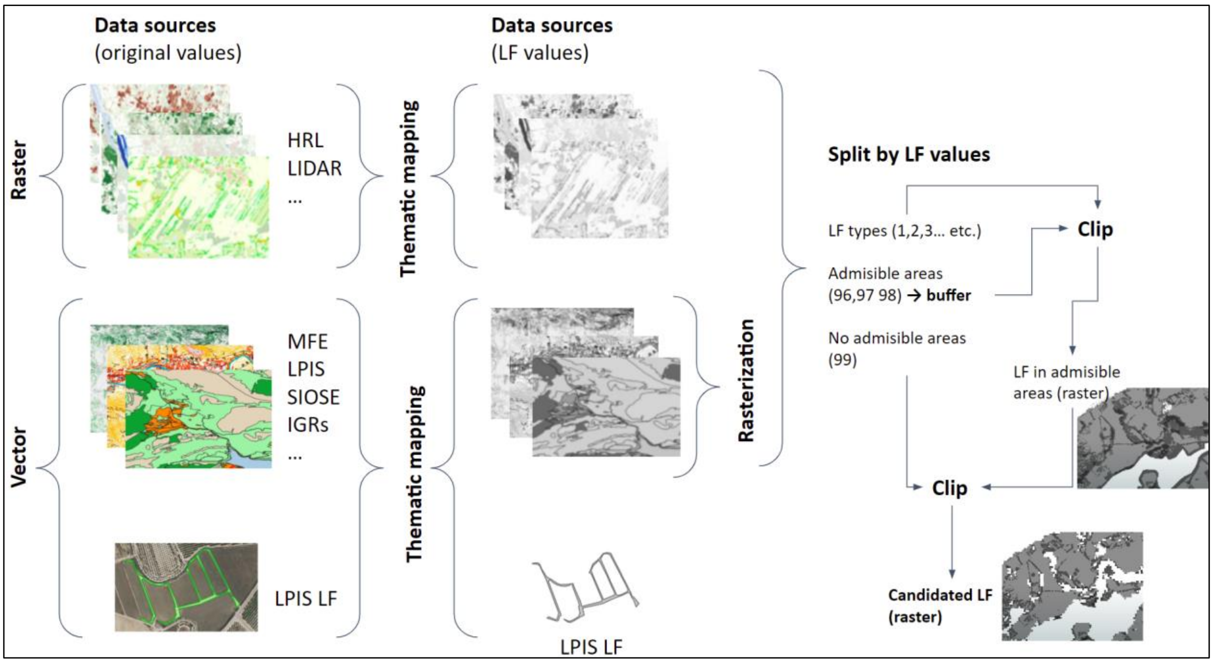
In addition, the searching for reliable data sources for grassy and stony classes was difficult because there are not national information products that allows to identify this type of landscape features.

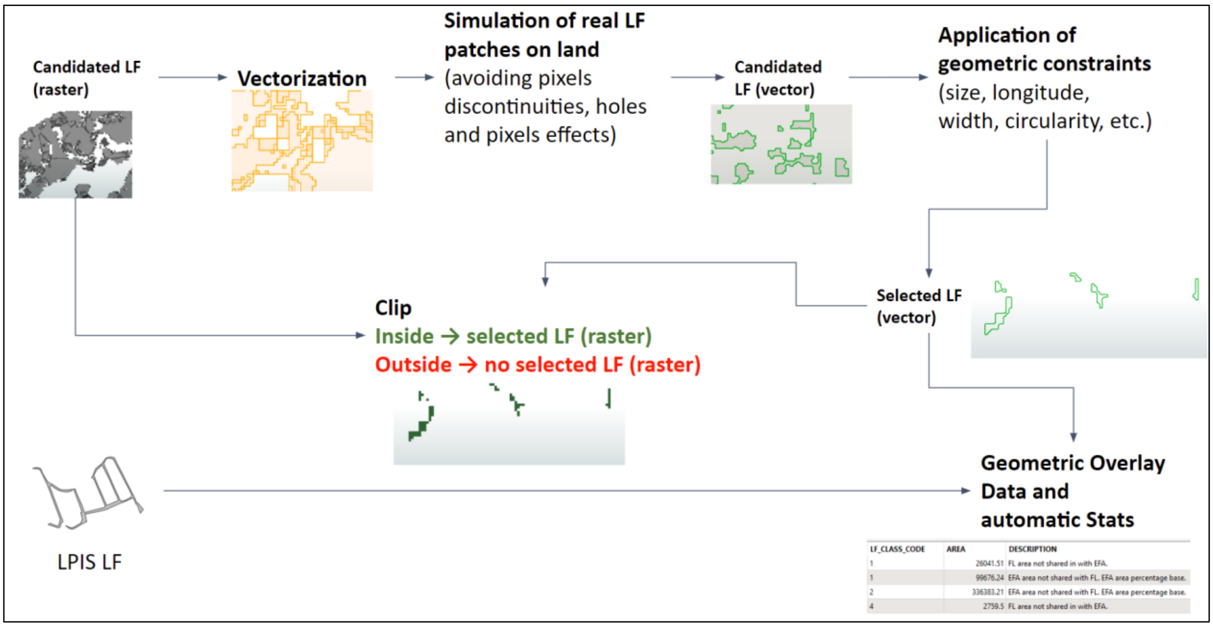
3.2. Production a LF dataset by automatic integration of available data

The objective was to generate automatically a national reference **Pilot LF layer** integrating the useful and available information previously analysed to be able to detect the LF in the next steps.

It is possible to integrate the selected data sources for getting an automatic LF layer, by definition of semantic and overlapping mapping rules among source classes and target classes. In order to carry it out, a process with **ETL tools (Safe Software | FME | Data Integration Platform)** has been generated. Starting exclusively from the original sources, this process consists of rasterizing the information layers, classifying them according to the elements of the landscape, combining them to obtain an automatic identification of expected LF classes.

In the following scheme is described the steps and workflow:





On the processes definition the following aspects have been taken into account:

- Thematic mapping: The source thematic classes of the selected information sources have been classified into the 4 types of **target LF classes** to obtain: woody, grassy, wet and stony. These classes have the following characteristics:

Class	Type	Comments
1	Woody_LF	Isolated trees, Tree lines and avenues, hedges, woody strips, trees in group, field coppices and riparian woody vegetation
2	Grassy_LF	Grassy strips, field margins, embankments, buffer strips, grassed 'thalweg'
3	Wet_LF	Inland channels of fresh water, standing small water bodies such as natural or man-made ponds, ditches.
4	Stony_LF	Dry stone walls, terrace elements, rock outcrops, natural or artificial stacks of stone.

- The sources are rasterizing after the thematic assignation. There is no priority among information sources, because all of them can generate LF's candidates. The selected LF elements of the PILOT LF Layer will depend on the defined **geometric criteria**.

- The study land is divided into **admissible** or **non-admissible** areas of LF, to reduce the calculation and the search area, and identify possible candidate areas susceptible to LFs. This regionalization of the territory is used to make different clips to the origin sources. For this purpose, codes are created to identify the terrain depending on the type of source:

Class	Type	Comments
96	**Admisible_LF**	Default class to represent areas where the existence of LF is possible (with the conditions: value 1 from LIDAR removal)
97	**Admisible_LF**	Default class to represent areas where the existence of LF is possible (with the conditions: removal of 1 and 2 values for any source information)
98	**Admisible_LF**	Default class to represent all those areas where the existence of LF is possible without conditions
99	**None_LF**	Default class to represent all those areas where the datasets ensure that there cannot be LF (negative class)

- The candidate pixels within the previously defined areas were vectorized. **Geometric criteria** are applied to the vector geometries (e.g. width, length and area) to identify each of the LF classes to generate a final identification in the Pilot LF layer. The definition of the geometric criteria is extremely sensitive to the final result. Vector geometries that meet the criteria are used to identify the original pixels of the sources. The thresholds for these criteria are those defined by the JRC:

Functional LF (FLF) class	Examples from GAEC/EFA	Proposed geometric specifications
Woody features	Isolated trees, Tree lines and avenues, hedges, woody strips, trees in group, field coppices and riparian woody vegetation	width >= 1 m AND (width <= 20 m OR area <= 0.5 ha)
Grassy features	Grassy strips, field margins, embankments, buffer strips, grassed 'thalweg'	width >= 1 m AND (width <= 20 m OR area <= 0.5 ha)
Wet features	Inland channels of fresh water, standing small water bodies such as natural or man-made ponds, ditches.	width >= 1 m AND (width <= 20 m* OR area <= 0.5 ha)
Stony features	Dry stone walls, terrace elements, rock outcrops, natural or artificial stacks of stone.	(width OR height) >= 1m AND (width <= 20 m OR area <= 0.5 ha)**

- In the later steps of the process, the simulated LF classes from the Pilot LF layer are automatically overlaid with the photointerpreted Spanish LFs available in the LPIS.

- The process calculates **statistics** of the crossing and overlap between the simulated LFs and the Spanish LFs available in the LPIS. The result of the LFs obtained is **visually reviewed by sampling** to control the approximate percentage of success between the different classes for the determination of errors obtained.

- If the result is not good, the simulation criteria are modified**,** so the process is iterative until the best possible result is achieved. This aspect has involved a high workload.

It is important to note that, as it is an automatic process for the generation of a Pilot LF layer that integrates the multiple available useful information sources, numerous iterations and tests have been necessary to achieve the interoperability of the different data sources and to reach the classification, consisting of modifications in the geometric and classification criteria on data sources as well as trial and error testing

of possible technic alternatives to define the best selection of criteria and sources, with the aim of developing a quality product that fits the land reality.

That is due to each iteration seeks to improve the results, however when the process focused on a target class is calibrated, it is possible to decalibrate the result for another target class.

For these reasons, the iterations to classify the different sources of information as 96, 97, 98 or 99, or as class 1, 2, 3 and 4, have taken more time than initially planned in the project.

Although we estimate that the obtained result offers the lowest joint error for all classes, as it is an automatic process, it has limitations in the precision of geometric and semantic results, so it is considered appropriate to control the results from the automatisms through photo-interpretation techniques.

Number of iterations	Observations
20 iterations carried out to define the sources of information to be used, geometric criteria, sampling and interpretation of results	• Hard to find a balance in the iterations between sources of information and geometric criteria. • LiDAR Vegetation causes many commission errors in classes 1 and 2. It has been necessary to discriminate it by means of classes 96,97,98 and 99. • Sometimes, European sources of information have poor resolution or do not reach an accuracy of 85%. For this reason, its inclusion in the process can generate unreliable results. The presence of some of them had to be ruled out. • Each iteration carried out has led to its work of interpretation of results, sampling, photo-interpretation and search for criteria to define the next iteration.

3.3. Direct mapping LF (photointerpretation)

As it was commented in point 3.1, the current national reference layer of **Landscape Features of the LPIS (LPIS LF layer)** was used to validate the reliability of the information generated automatically in point 2. There was no actual direct mapping of LF in this work.

This LPIS LF layer is based on the Methodology for Identification of LF by Photo-Interpretation that defines the system used for the identification of LPIS. This work consists of the digitisation, such as geometries, lines or points, of LF that are observed by photo-interpretation within the LPIS RP of **declared arable land and permanent crops**. The work of identifying these elements has followed a series of criteria depending on their size, which vary according to the type of element.

<u>Considerations of the methodology for the LPIS LF Layer:</u>

a) It regards as LF those listed in Royal Decree 1078/2014, on cross-compliance, which form part of the total area of the agricultural parcel.
b) The identification of the LF focuses on the areas eligible and declared with LPIS use of **arable land (LA)** and **permanent crops (CP)**. Eligible **grassland and pasture (P)** areas are initially excluded from photo-interpretation.
c) RP with high concentration of terraces, terraces or banks (for instance on areas of permanent crops and irrigated arable land): identification of all linear elements of the RP as a set (without individual identification of each LF) and with LF code “RT”.
d) The 3 layers are temporary: it allows the LFs to be maintained and retain the historical changes for monitoring and checking the conservation of LFs. The layers also provide information on the causes of developments and changes to registers.
e) Geometric criteria. Maximum and minimum size limits established for the different types of areas that could be considered LF:

Limit according to EU Delegated Regulation 639/2014 (Article 45)
Shared limit RD and Regulation
Limit according to Conditionality Royal Decree (RD 1078/2014)
Limit established for the photo interpretation

LF TYPE	Criteria	Max	Min	Comments
Hedges	Width (m)	10	2	
	Length (m)		25	
Isolated trees	Treetop Diameter (m)		4	
Tree lines	Treetop Diameter		4	
	Gaps between trees (m)	5		
	Length (m)		25	
Trees in group or field coppices	Surface (m2)	3.000	200	
Vegetation zones/Stone stacks	Surface (m2)	1.000	100	
Field margins	Width (m)	10	2	The Regulation establishes a width between 20 - 1 m
	Length (m)		25	
Ponds	Surface (m2)	1.000	100	
Terraces	Width (m)	10	2	The Regulation indicates that the MS will establish criteria
	Length (m)		25	
Traditional architecture	Surface (m2)		51	

* Minimum limits were set to streamline the work of photo-interpretation. In other words, it is possible to register LFs of a smaller size than those indicated, even if they have not been identified in the photo-interpretation, taking into account the minimum limits laid down in Article 45 of Delegated Regulation 639/2014.

f) Not all types of LF can be identified by photo-interpretation in all LPIS uses (e.g.: Trees in PC parcels: risk of incorrect identification of cultivated trees as LF). *Groups of LPIS agricultural uses: arable land (LA); permanent crops (CP); grassland/pasture (P)

	AL	PC	P	Comments
Hedges	OK	POSSIBLE	NO	e.g. Windbreakers
Isolated trees	POSSIBLE	POSSIBLE	NO	Id by the AACC. Unique trees
Tree lines	OK	POSSIBLE	NO	
Trees in group or field coppices	OK	POSSIBLE	NO	e.g. Vineyard
Vegetation zones / Stone stacks	OK		NO	
Field margins	OK		NO	
Ponds	OK		NO	
Terraces	OK		NO	
Traditional architecture				No planned to Id

g) General criteria for LF Not identified by photo-interpretation:
- Grassland/Pastures RP: no LF will be identified on them, but LF can be identified as a continuation of a LF already identified in other contiguous eligible areas.
- Traditional architecture (e.g. dry stone walls, old pigeons): not planned to identify it by photointerpretation.
- Single trees: no planned to identify it by photointerpretation. But AACC can save them in the case of being unique.
- Areas recorded in the LPIS as ineligible (e.g. Forest area): not planned to identify by photointerpretation LF on them, but exceptions laid down by the AACC.
- Overruns of vegetation masses from contiguous parcels bordering the RP subject to photo-interpretation, even if they are of eligible uses: not planned to identify it by photo-interpretation.
- Lands in an apparent state of abandonment: not planned to identify by photointerpretation LF on them.
- Field margins or terraces on the edges of roads and vials (e.g. roadside ditch): no planned to identify it by photointerpretation, but exceptions laid down by the AACC.
- Riverside vegetation overruns on the edges of watercourses: planned to identify it by photointerpretation, but exceptions laid down by the Autonomous Community. *Areas already identified and not considered as LF: it is not foreseen to be eliminated as being eligible as buffer strips.
- Balance of rice fields: not planned to identify it by photointerpretation, but exceptions laid down by the Autonomous Community.

h) General criteria for LF Yes identified by photo-interpretation:
- The identification by photo-interpretation of LF will focus on elements included, in whole or in part, on eligible RP declared with AL and PC uses.
- LF included in whole or in part in the RP under consideration: they shall be identified independently of the LPIS uses of the surrounding RP and their delimitation or identification shall be complete, providing continuity outside the initial RP to the geometries or lines with which they are identified.

i) Measures applied in photo-interpretation:
- Verification of the size of a LF is carried out in the light of the LF as a whole and not only of the part entered in the RP declared subject to photo-interpretation.
- LF located between a declared RP and its non-declared neighbours: delineate the geometry, or line that defines the identified LF, without cutting it to the boundary of the RP being studied.

The figures of the **number of LF** identified by photointerpretation of eligible agricultural land, focused on superfaces with aid application of arable land and permanent crops, and registered in LPIS, january 2022 are:

POLYGONS LAYER

Isolated trees	Tree lines	Trees in group (Field coppices)	Ponds	Traditional architecture	**Vegetation zones**	**Field margins**	Stone walls	Mixed	Parcels with terraces	Undefined	Hedges	**Terraces**	TOTAL
		46.300	13.464	4.264	**518.093**	**99.912**	5.710	2.521	15.059	47.322	1.397	**157.002**	911.044

LINES LAYER

Isolated trees	Tree lines	Trees in group (Field coppices)	Ponds	Traditional architecture	**Vegetation zones**	**Field margins**	Stone walls	Mixed	Parcels with terraces	Undefined	Hedges	**Terraces**	TOTAL
	59.167		16	64	326	**864.404**	3.643	98		51	1.887	**1.121.964**	2.051.620

POINTS LAYER

Isolated trees	Tree lines	Trees in group (Field coppices)	Ponds	Traditional architecture	**Vegetation zones**	**Field margins**	Stone walls	Mixed	Parcels with terraces	Undefined	Hedges	**Terraces**	TOTAL
37.364			5	2.499	86	21	32	0		1	0	34	40.042

TOTALES

Árboles	Árboles en linea	Árboles en grupo	Charcas	Construcciones	**Islas o enclaves**	**Lindes**	Muros	Mixto	Recintos con terrazas	Elementos sin definir	Setos	**Terrazas**	**TOTAL**
37.364	59.167	46.300	13.485	6.827	**518.505**	**964.337**	9.385	2.619	15.059	47.374	3.284	**1.279.000**	**3.002.706**

Examples of linear and polygonal LFs in the LPIS LF Layer:

3.4. Overlay LF datasets (overlay 3.2. and 3.3 products)

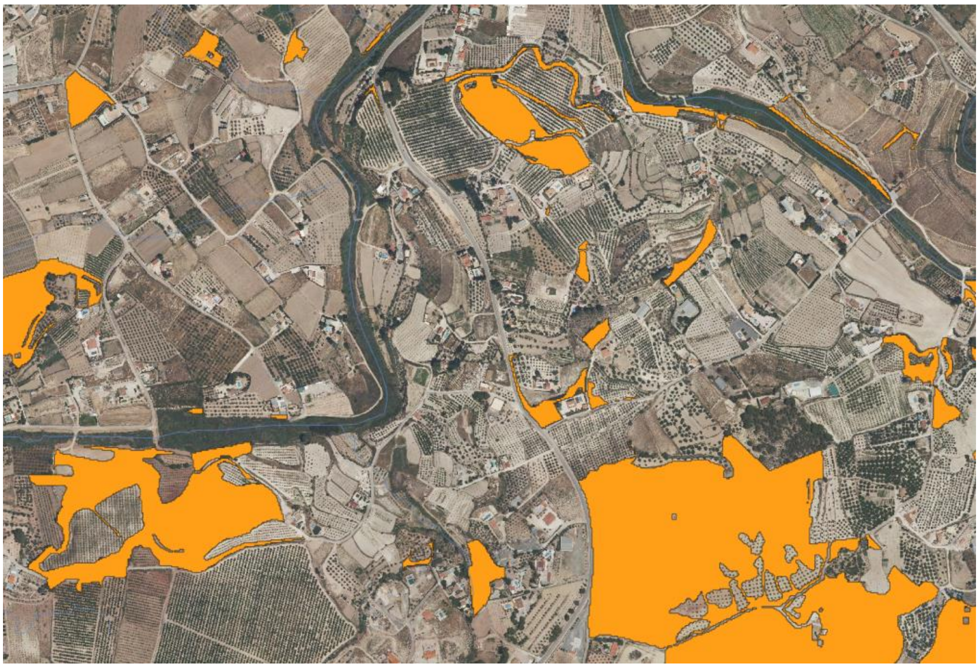
The LFs data of the automatic integration of the reference data sources generated in phase 2, PILOT LF Layer was overlayed with the LF layer of the LPIS, allowing to compare and assess.

The result layers obtained after carrying out the automatic process and subsequently used for the analysis and completion of the 'Visual comparison' phase have been the following:

- **Mask 96:** Raster layer. Default class to represent areas where the existence of LF is possible (with the conditions: class 1 from LIDAR (removal). You can find classes 1,2,3 y 4 but LiDAR Vegetation does not identify class 1 because in these areas it is not usual to find woody classes.

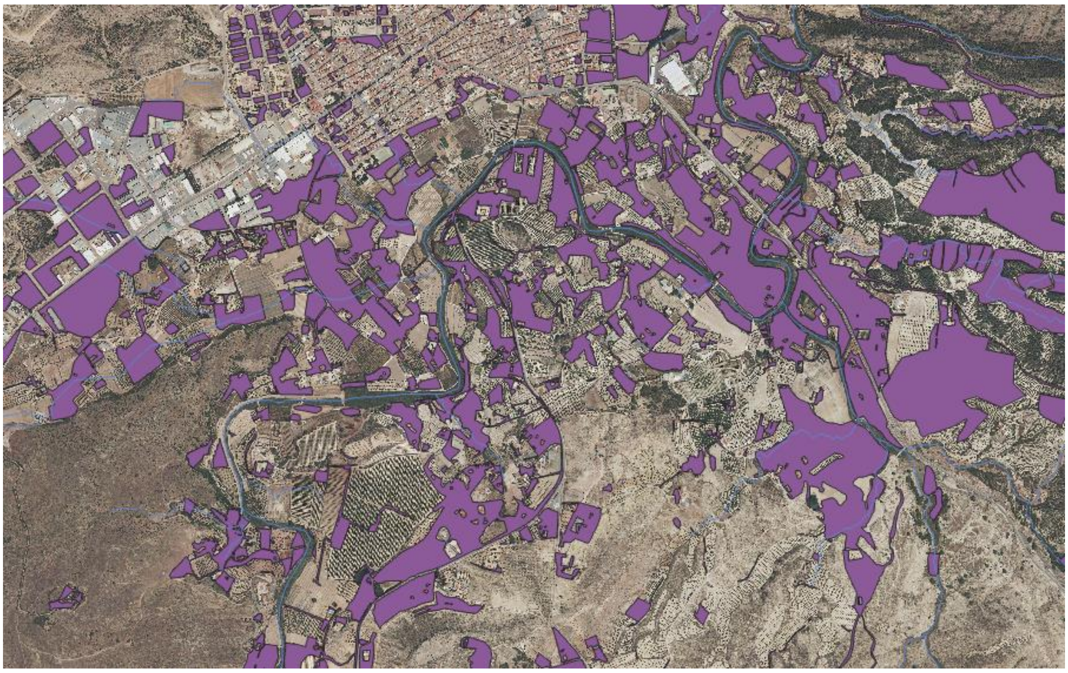
Mask 96 identification

- **Mask 97:** Raster layer. Default class to represent areas where the existence of LF is possible (with the conditions: removal of 1 and 2 values for any source information). These areas cannot have woody and grassy classes.



Mask 97 identification

- **Mask 98:** Raster layer. Default class to represent areas where the existence of LF is possible without particular exceptions. These areas can contain woody, grassy, wet and stony classes. This class does not discriminate any LF class.

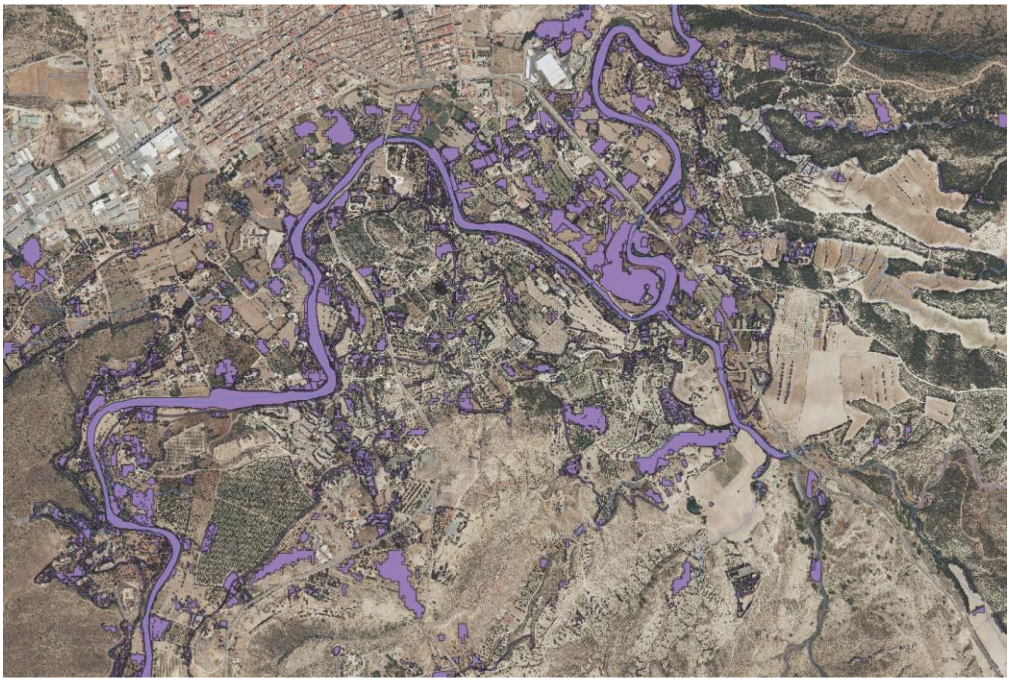


Mask 98 identification

- **Mask 99:** Raster layer. Default class to represent all those areas where the datasets ensure that there cannot be LF (negative class). Streets, roads, buildings, etc.

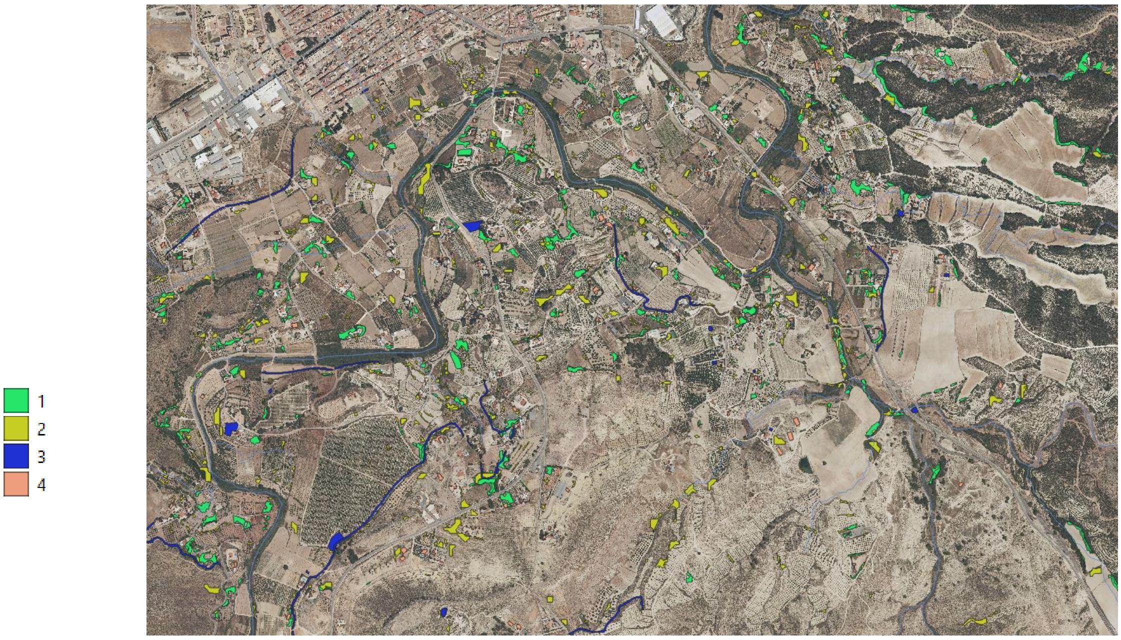
Mask 99 identification

- **Vector_candidated_areas:** Vector layer. LF results without discriminating geometrical criteria. These areas show possible areas that could be LF classes.



Vector candidate areas identification

- **Vector_selected_area:** Vector layer. Final results of LF classes selected. Every polygon has a dataset information and its 'LF class'. This layer is later evaluated in the phase 5.



Vector selected areas identification

- **Vector_coincident area_CLIP:** Vector layer. This layer shows the overlap areas between Vector_selected_area and LPIS LF.

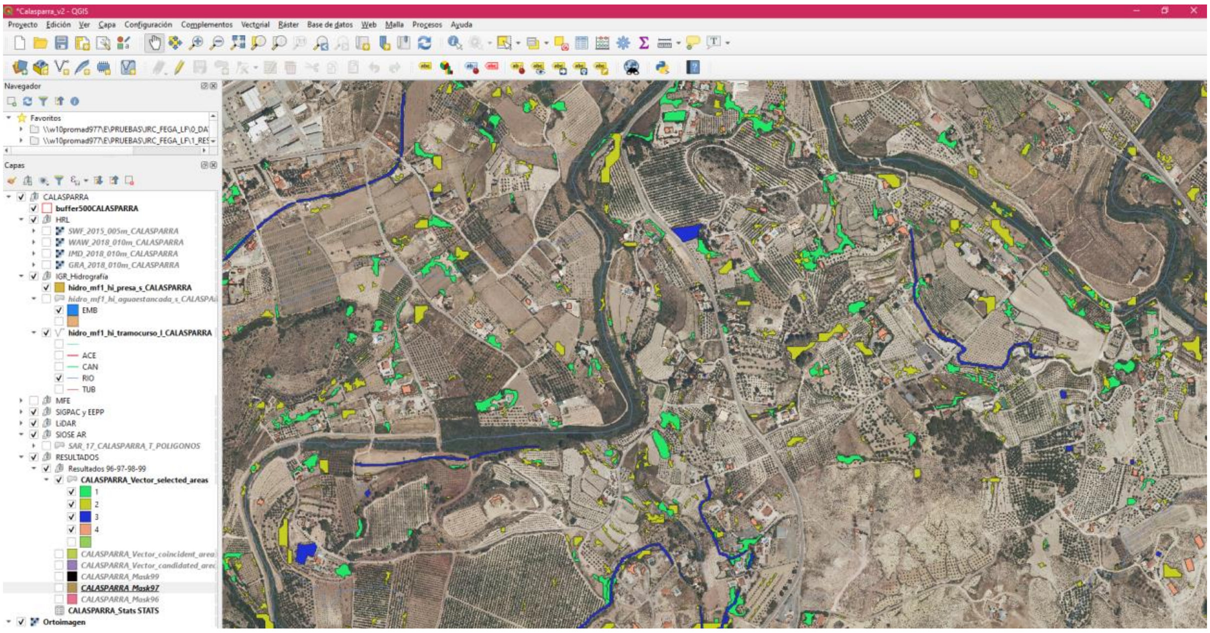
Vector coincident areas identification

- **Vector_coincident area_OVERLAY:** Vector layer. This layer shows the overlapped areas where there are a Vector_selected_area and LF of LPIS, without clipping.

Vector coincident areas identification

To carry out the visual and statistical comparison and obtain the conclusions of the results, a project has been prepared in QGIS with all the layers for each of the study areas.

The QGIS project contain the selected information sources in order to analyse the results in a visual way (point 5).



QGIS project: Calasparra

3.5. Visual comparison, stats

In this phase, it was determined the coincidence degree of the available sources with the reality of the terrain. This study was carried out for each pilot area and each LF functional class established by the JRC.

The most recent orthophoto available was used.

Once the automatic layer of landscape elements obtained by FME is available, it is time to perform a detailed visual evaluation comparison of the work with the photo-interpreted landscape elements from the LPIS LF layer.

This review should be understood as a validation of the automatic result, which provides a knowledge of the reliability of the layer as objective as possible. For this purpose, a series of review boxes were performed, in which:

- For each LF target class, the correctness of the landscape elements identification was denoted following a graded scale: excellent, good, acceptable, low, insufficient.
- Point taking showing examples of good and bad identifications.

All this work provided the results presented below, as well as the knowledge necessary to draw conclusions.

Before presenting the results, a series of **considerations** will be made, as well as the **methodology** that was developed. On the one hand, it should be taken into account that the LPIS LF layer, although it contains fewer identified elements than the Pilot LF layer, does not mean that it is wrong, but simply that the photointerpretation focuses mainly on the reference parcels declared with use of cropland and permanent crops, as well as mowing meadows.

Likewise, there are omissions in the LPIS LF layer that correspond to elements that are not currently considered landscape elements in Spain, such as river protection strips or irrigation ditches. However, the identification of this type of elements was also studied with a view to future years and possible changes in the Common Agricultural Policy.

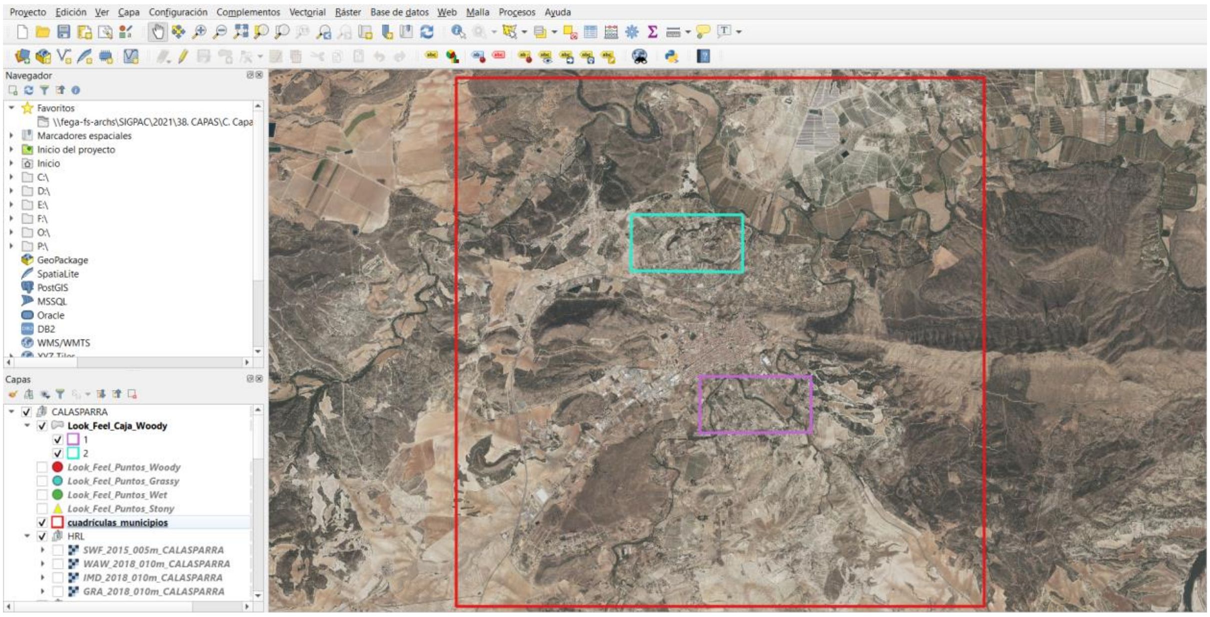
In addition, before the photointerpretation exercise, it should be taken into account that the reference parcels of arable land, permanent crops and pasture, it was planned to identify landscape elements in reference parcels of non-productive use, since they are portions of land that due to their physical characteristics do not provide any agricultural production; however, depending on the characteristics and dimensions of the element/elements contained in the reference parcel, it can be considered a Landscape Element. Furthermore, it was planned to identify landscape elements in reference parcel of water use.

In order to understand what type of landscape elements can be identified in non-productive and water use reference parcels, is shown below the definition included in the "General Rules for the Identification and Delimitation of LPIS Exploitations" developed by the Spanish Agricultural Guarantee Fund in order to establish the basic rules for the delimitation and identification of LPIS exploitations.

- **Non-Productive (IM) LPIS Use:** Portion of land that due to its physical characteristics does not provide any agricultural production (rocky outcrops, quarries, gravel pits, salt pans, dunes, etc.). This use will also be assigned in SIGPAC when different non-productive areas (buildings, roads, streams and water surfaces, etc.) that are adjacent to each other can be grouped together.
  Non-productive use reference parcels will be considered the uncultivated margins/boundaries of any enclosure, with presence of spontaneous/woody vegetation, except when it is considered a Landscape Elements protected by the conditionality rules, and other cases of surfaces with vegetative activity, as long as they do not support agricultural production or livestock use.
  For the review work by photointerpretation, if the width of this margin does not exceed 10 meters, it will be considered a reference parcel IM enclosure, unless, due to its characteristics, it is considered a Landscape Element. On the other hand, if the uncultivated margin with spontaneous/woody vegetation exceeds these maximum dimensions, it will be considered as a reference parcel and will be assigned the corresponding shrub grass (PR), woody grass (PA) or foresty (FO) use.
  However, during field visits, the physical characteristics of the observed terrain shall be taken into account, and regardless of the width of said uncultivated margin, said margin shall be considered as an enclosure, assigning it the corresponding use, unless, due to its characteristics and width, it is considered a Landscape Element.
  This use shall also be assigned to enclosures with grass-like coverage whose use is not predominantly agricultural, such as recreational parks, sports facilities, golf courses, urban parks, etc
- **Water (AG) LPIS Use**: Portion of land occupied by rivers, streams, irrigation ditches, wadis, lakes, reservoirs, etc. of natural or artificial origin, regardless of the existence of water or not at the time the reference parcel is studied. Also considered as AG are the cadastral plots of land with a use equivalent to water, regardless of its use.

Then, for each region, the **method** followed during the visual comparison exercise is described below:

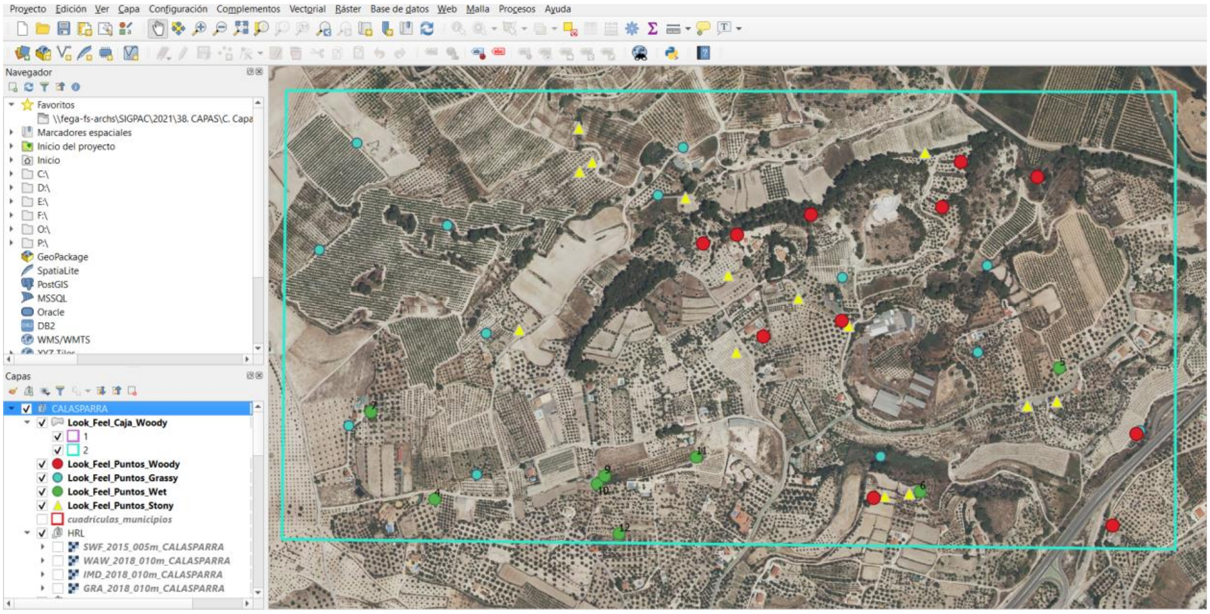
- The selected national reference data, the SIGPAC landscape elements and the generated automatic pilot LF layer are imported into **QGIS**.
- Within the QGIS project, for each region, a polygon type layer is created where two grids called <u>boxes</u> are digitized (Look_Feel_Caja.shp), which allow the selection of the samples of landscape elements that have been photointerpreted in each region. For this step, it was taken into account that the two boxes for each reagion were representative in terms of landscape elements identified by the LPIS LF layer and the Pilot LF layer.



- QGIS project: Calasparra (Murcia)

- Then, for each region, four <u>point layers</u> are created to identify and describe the element samples obtained by the pilot layer for each element class: Woody (Look_Feel_Puntos_Woody.shp); Grassy (Look_Feel_Puntos_Grassy.shp); Wet (Look_Feel_Puntos_Wet.shp) and Stony (Look_Feel_Puntos_Stony.shp).

- It should also be noted that the number of photo-interpreted landscape elements was based on the number of elements present in each of the boxes of the pilot layer and the LPIS layer.



- QGIS project: Calasparra (Murcia)

In the **process of verification and visual comparison**, several errors were detected. Errors of commission, omission, semantic and geometric errors were found; however, elements identified correctly were also found. A general overview and summary tables with the results of the sample for each of the regions are shown below.

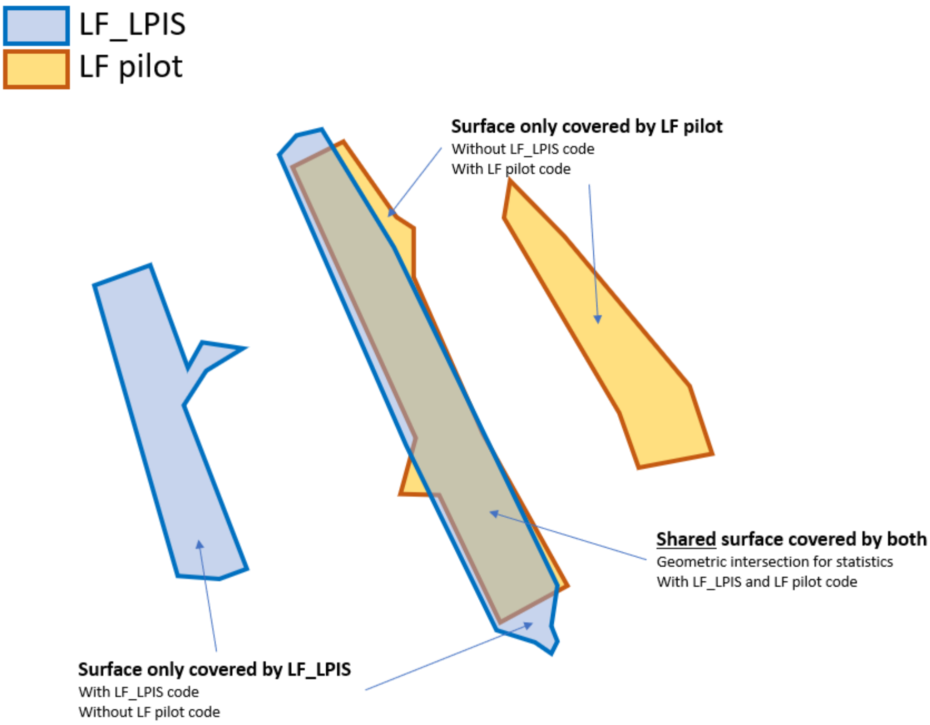
For the **evaluation of the samples**, an overview of the quality of the Pilot LF Layer was established, where each group of elements as well as each sample was evaluated in five grades:

Grade	**Description**
excellent (1)	It means that the accuracy of Pilot LF Layer is expected to reach almost 100%, practically no errors can be found in the verified area.
good (2)	It means that the operator is confident that the accuracy of the Pilot LF Layer is high, only sporadic errors are found in the checked areas.
acceptable (3)	It means that the accuracy of the Pilot LF Layer is estimated to be permissible in most of the areas checked, although minor errors may be detected in the areas checked.
poor (4)	It means that the accuracy of the Pilot LF Layer is not expected to be good, several errors are found in different areas.

insufficient (5)	It means that the operator is confident that the accuracy of the Pilot LF Layer is poor, most of the verified areas are poorly mapped.

- **Global summary:**

In relation to the results obtained from the comparisons between the **Pilot LF Layer** and the **LPIS LF Layer** (used as a reference), the surfaces and percentages of coincidence and discrepancy between the two layers are shown below.



LF geometries resulting from the pilot project are contrasted, in statistic way, with the actual LF exiting in the national LF LPIS Layer. Joining both data layers build a unique layer with possible overlaps among geometries, some coming LF_LPIS and others from LF pilot. A simple geometric intersection can determine which area is covered by one o by both. Area covered only by LF_LPIS will have only LF_LPIS class identification code. Area covered only by LF pilot will have only LF pilot class identification code. Area covered by both will have LF_LPIS and LF pilot class identification code. Class codification follows the proposed general values (1 woody, 2 grassy, 3 wet, 4 stony). LF_LPIS original codification has been translated into these values.

The following Table A is on those LFs located on reference parcels **declared** by the farmer and for **overlapping** LF classes between both layers, such as: Woody LF with Woody LF on both; or Stony LF with Stony LF; etc.

	LF_LPIS	Suma de AREA	Area	Area percentage per LF_LPIS class	Total area percentage	Comments[1]
	1	**67.416**		100%		
LF pilot	1	64.876	64.876	96,23%	1,15%	Class coincidence
LF pilot	2	2.265	2.540	3,77%	0,04%	Semantic error
LF pilot	3	106				
LF pilot	4	169				
	2	**297.522**		100,00%		
LF pilot	1	166.755	90.359	30,37%	1,60%	Class coincidence
LF pilot	2	90.359	207.163	69,63%	3,67%	Semantic error
LF pilot	3	39.345				
LF pilot	4	1.062				
	3	**271**		100%		
LF pilot	1	186	0	0,00%	0,00%	Class coincidence
LF pilot	2	85	271	100,00%	0,00%	Semantic error
	4	**433.471**		100%		
LF pilot	1	221.143	1.474	0,34%	0,03%	Class coincidence
LF pilot	2	200.073	431.997	99,66%	7,65%	Semantic error
LF pilot	3	10.781				
LF pilot	4	1.474				
	(empty)	**4.846.735**		100,00%		
LF pilot	1	2.245.640	2.245.640	46,33%	39,78%	New LF indentified, comissions
LF pilot	2	1.643.922	1.643.922	33,92%	29,12%	New LF indentified, comissions
LF pilot	3	688.695	688.695	14,21%	12,20%	New LF indentified, comissions
LF pilot	4	268.478	268.478	5,54%	4,76%	New LF indentified, comissions
	Overall total	**5.645.415**			**100,00%**	

Table A. Results considering semantic errors, LF pilot codes assignation to a distinct LF_LPIS code.

[1] Due to LF_LPIS were not considered in not declared area, provokes that there is not exist empty values of LF_LPIS in the pilot layer. It is not possible to consider omission errors

Taking into consideration letter b of point 3.3 of this report, which indicates that the LPIS landscape element identification methodology only identified elements on **eligible** and **declared** reference parcels, this makes the percentage of coincidence between both layers is higher for the Woody and Grassy LF, since most of these LF types digitized in the Pilot are in found on eligible and declared surfaces in the LPIS (which are the ones on which the LPIS LF Layer was focused). In the case of Stony LF, the percentages are low due to the difficulty of correctly detecting and identifying elements such as heaps or stone walls with the resolution of the reference sources.

Observing data in Table A, and taking into account the area of intersection of landscape elements in the resulting intersection layer, for the landscape elements of Class 1 (Woody) the coincidence percentage is approximately 96%; this percentage is high due to the area that intersects between the Pilot LF layer and the LPIS LF layer. This percentage is approximately 30% for the Grassy class, and 0% for the Wet and Stony classes. Regarding the semantic errors, in the Woody class the percentage is low; for the Grassy class it is around 70% mainly due to the confusion of Grassy LF with Woody LF; and for the Wet and Stony classes the percentage is close to 100%. In the case of the Stony LF, it is fundamentally due to the detection of the terraces as if they were elements of the Woody or Grassy type (for example, rows of trees, boundaries).

As previously it was mentioned, the percentages of coincidence for the Wet and Stony classes are low for various reasons, among which are that landscape elements belonging to the Wet class are found fundamentally in enclosures with water use (AG), LPIS use that it is not declarable by farmers. Likewise, the low coincidence may be related, in the case of Stony LF, to the difficulty of correctly detecting and identifying elements such as heaps or stone walls with the resolution of the reference sources.

On the other hand, the area that has been detected as commissions of the LF Pilot Layer is 4,846,735 square meters with respect to the total 5,645,415 square meters.

On the other hand, the following Table B shows the intersection of the **Pilot LF layer** with the **LPIS LF layer** under the following considerations:

- It includes LF identified in the Pilot LF layer on **declared** and **undeclared** Reference parcels. That is to say, in this Project we have studied elements detected by the **Pilot LF layer** both in declared reference parcels and in reference parcels that were not declared by the farmer, so this part of the study on the Pilot LF layer of "parcels not admissible in the LPIS", such as those of unproductive use and water use, has allowed us to know the LF that can be located on these surfaces and that were not identified in the LPIS LF layer, which has been of special interest to analyze the Wet and Stony type elements.

	LF_LPIS	Sum of AREA	Area	Area percentage per LF_LPIS class	Total area percentage	Comments
	1	**268.093**		100%		
LF pilot	1	66.549	66.549	24,82%	0,47%	Class coincidence
LF pilot	2	2.423	2.767	1,03%	0,02%	Semantic error
LF pilot	3	106				
LF pilot	4	238				
	empty	198.776	198.776	74,14%	1,40%	No coincidence, missing LF, omissions
	2	**1.843.330**		100%		
LF pilot	1	171.366	92.544	5,02%	0,65%	Class coincidence
LF pilot	2	92.544	215.191	11,67%	1,51%	Semantic error
LF pilot	3	42.259				
LF pilot	4	1.567				
	empty	1.535.595	1.535.595	83,31%	10,78%	No coincidence, missing LF, omissions
	3	**2.609**		100%		
LF pilot	1	246	214	8,19%	0,00%	Class coincidence
LF pilot	2	85	331	12,69%	0,00%	Semantic error
LF pilot	3	214				
	empty	2.064	2.064	79,11%	0,01%	No coincidence, missing LF, omissions
	4	**3.876.098**		100%		
LF pilot	1	232.937	2.005	0,05%	0,01%	Class coincidence
LF pilot	2	210.719	455.238	11,74%	3,20%	Semantic error
LF pilot	3	11.582				
LF pilot	4	2.005				
	empty	3.418.855	3.418.855	88,20%	24,00%	No coincidence, missing LF, omissions
	(empty)	**8.254.865**		100%		
LF pilot	1	3.671.382	3.671.382	44,48%	25,77%	New LF indentified, comissions
LF pilot	2	2.726.554	2.726.554	33,03%	19,14%	New LF indentified, comissions
LF pilot	3	975.313	975.313	11,82%	6,85%	New LF indentified, comissions
LF pilot	4	881.616	881.616	10,68%	6,19%	New LF indentified, comissions
	Total	**14.244.995**			**100,00%**	

Table B. Results considering semantic errors, LF pilot codes assignation to a distinct LF_LPIS code

Looking at data in Table B, and taking into account the intersection area of landscape features in the resulting intersection layer, for Class 1 (Woody) landscape features, the coincidence percentage is approximately 25%. To calculate this percentage, the area that intersects between the Pilot LF layer and the LPIS LF layer has also been taken into account. This percentage is approximately 5% for the Class 2 (Grassy), 8% for the Class 3 (Wet), and 0,1% for the class 4 (Stony). In the case of this Table B, and continuing with what was indicated above, the results of LF Wet are of special interest because they can be detected in areas of non-declarable use by farmers. However, the low coincidence may be related, in the case of Wet LF, to regions with a predominance of pastures and ponds that exist in the pastures are probably temporary and therefore are often not identified, as this will depend on the time of photo interpretation.

Regarding the semantic errors, for the Woody class the percentage is very low, and for the Grassy, Wet and Stony classes around 12% each.

- **Summary for each region and for each type of element:**

1. **<u>Calasparra (Murcia)</u>**

LF CLASS	OVERALL SITUATION[2]	DESCRIPTION
WOODY	acceptable	Twenty-eight samples have been analyzed, of which approximately 45% have an 'insufficient' result due to the commissions detected since they delimit woody LF when in fact they correspond to trees that are part of a permanent crop reference parcel. However, approximately 35% of the samples have good geometric accuracy and are 'good and acceptable' thanks to the good delimitation of elements that are detected such as hedges, groups of trees or protection strips of watercourses. It also detects terraces in an acceptable way although they present a semantic error since they are Stony LF. So, it can be said that the elements that it does identify have good geometric accuracy.
GRASSY	acceptable	Twenty-eight samples were analyzed, of which 35% are 'insufficient' due to the commissions and omissions detected, since they delimit grassy LF when in fact they correspond to areas of a reference parcel of arable land or permanent crop, or because they do not detect some field margins between plots. However, approximately 30% of the samples are 'good',

[2] This is an overall assessment considering the results of each element as a whole.

LF CLASS	OVERALL SITUATION[2]	DESCRIPTION
		mainly due to the good geometric accuracy of the field margins that it does detect.
WET	acceptable	Twelve samples have been analyzed of which 75% have an 'insufficient' result. This is due to a high number of commissions as it detects that there are wet LF that do not really correspond to landscape elements as they are made of cement or plastic based. However, the elements it detects correctly are 'excellent' and good such as irrigation ditches and ponds.
STONY	poor	Thirty-one samples have been analyzed, of which approximately 70% have an 'insufficient' result. This is due to the high number of commissions because it delimits buildings that are not landscape elements because they are not elements of traditional architecture. However, it should be noted that the terraces are not delimited since the Pilot LF layer identifies them as grassy LF so they present a semantic error. Furthermore, it is indicated that there is not enough geometric precision to identify Stony LF

Defined group	Commission	Omission	Semantic error	Correct	Overall total
Woody LF	11	1	7	9	**28**
excellent (1)					**0**
good (2)			2	4	**6**
acceptable (3)			2	2	**4**
poor (4)			3	3	**6**
insufficient (5)	11	1			**12**

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
Grassy LF	4	6	6	12	**28**
excellent (1)					**0**
good (2)				8	**8**
acceptable (3)			5	2	**7**

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
poor (4)			1	2	**3**
insufficient (5)	4	6			**10**

Defined group	Commission	Correct	Overall total
Wet LF	9	3	**12**
excellent (1)		1	**1**
good (2)		2	**2**
acceptable (3)			**0**
poor (4)			**0**
insufficient (5)	9		**9**

Defined group	Commission	Omission	Semantic error	Correct	Overall total
Stony LF	15	7	8	1	**31**
excellent (1)					**0**
good (2)				1	**1**
acceptable (3)			7		**7**
poor (4)			1		**1**
insufficient (5)	15	7			**22**

2. Monzón (Huesca)

LF CLASS	**OVERALL SITUATION**	**DESCRIPTION**
WOODY	acceptable	Thirty samples have been analyzed, 30% of which have an 'acceptable' result. This is due to the fact that most of the detected woody elements present a low geometric error, however, they present a semantic error since they actually correspond to field margins between plots (Grassy LF) or terraces (Stony LF).

LF CLASS	OVERALL SITUATION	DESCRIPTION
GRASSY	acceptable	Thirty samples have been analyzed, of which approximately 40% are 'insufficient' due to the commissions and omissions detected because they delimit grassy LF when in fact they correspond to areas of a reference parcel of arable land or permanent cultivation, or because they do not detect some field margins. However, 33% of the samples are 'acceptable' thanks to the good geometric accuracy of the field margins it does detect. It also detects terraces acceptably, although they present a semantic error because they are Stony LF.
WET	insuficient	Twenty samples have been analyzed of which 60% have an 'insufficient' result. This is due to a high number of commissions as it detects that there are Wet LF when in fact there is vegetation. In this case, this is due to the fact that in the information source the reference parcel had been classified as water, so it cannot be attributed to a misidentification of the Pilot LF layer. However, the elements that it detects correctly are excellent and good such as ditches and ponds.
STONY	poor	Twenty samples have been analyzed of which 75% have an 'insufficient' result. This is due to the high number of commissions and omissions detected because it delimits buildings that are not landscape elements because they are not elements of traditional architecture. In addition, there are omissions because it does not delimit terraces since they are detected as Woody LF. However, the elements that are detected are done so in an adequate way. Furthermore, there is not enough definition to recognize Stony LF.

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
Woody LF	5	3	13	9	**30**
excellent (1)				5	**5**
good (2)			2	1	**3**
acceptable (3)			7	2	**9**
poor (4)			4	1	**5**
insufficient (5)	5	3			**8**

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
Grassy LF	7	5	5	13	**30**
excellent (1)					**0**
good (2)				7	**7**
acceptable (3)			5	5	**10**
poor (4)				1	**1**
insufficient (5)	7	5			**12**

Defined group	Commission	Semantic error	Correct	**Overall total**
Wet LF	12	2	6	**20**
excellent (1)			4	**4**
good (2)			1	**1**
acceptable (3)		2	1	**3**
poor (4)				**0**
insufficient (5)	12			**12**

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
Stony LF	15	7	2	6	**30**
excellent (1)					**0**
good (2)			1	6	**7**
acceptable (3)					**0**
poor (4)			1	1	**2**
insufficient (5)	15	7			**23**

3. Villaviciosa (Asturias)

LF CLASS	OVERALL SITUATION	DESCRIPTION
WOODY	acceptable	This is an area where the bocage is characteristic, that is a landscape made up of small reference parcels separated from each other by hedges, trees in lines. Thirty samples have been analyzed, of which approximately 30% have an 'insufficient' result due to the commissions and omissions detected because it delimits woody LF when in fact they correspond to pasture areas or trees that are part of a permanent crop reference parcels, or because it does not detect some elements such as trees in lines or hedges. However, many elements such as trees in line are detected correctly and with good geometric accuracy, which allows 27% of the samples to be good. Therefore, it can be said that the elements that it does identify have good geometric accuracy.
GRASSY	poor	Thirty samples have been analyzed, of which approximately 60% are 'insufficient' due to the commissions and omissions detected because it delimits grassy LF when in reality they correspond to buildings and areas of a reference parcel of arable land or permanent crop, or because it does not detect some field margins between plots. However, it does correctly detect a large number of elements, although with geometric error.
WET	-	Only the one sample that corresponds to a commission has been analyzed. Therefore, no conclusions can be drawn for Wet LF.
STONY	insuficient	Twenty-two samples have been analyzed, of which approximately 100% have an 'insufficient' result. This is due to the high number of commissions because it delimits buildings that are not landscape elements because they are not elements of traditional architecture. Also, it is indicated that there is not enough definition to recognize Stony LF.

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
Woody LF	5	5	5	15	**30**
excellent (1)					**0**
good (2)				8	**8**
acceptable (3)			4	3	**7**
poor (4)			1	4	**5**
insufficient (5)	5	5			**10**

Defined group	Commission	Omission	Semantic error	Correct	**Overall total**
Grassy LF	11	8	4	7	**30**
excellent (1)					**0**
good (2)				2	**2**
acceptable (3)			1	2	**3**
poor (4)			3	3	**6**
insufficient (5)	11	8			**19**

Defined group	Commission	**Overall total**
Wet LF	1	**1**
excellent (1)		**0**
good (2)		**0**
acceptable (3)		**0**
poor (4)		**0**
insufficient (5)	1	**1**

Defined group	Commission	Correct	**Overall total**
Stony LF	21	1	**22**
excellent (1)			**0**
good (2)		1	**1**
acceptable (3)			**0**
poor (4)			**0**
insufficient (5)	21		**21**

4. Santa Cruz de la Sierra (Extremadura)

LF CLASS	OVERALL SITUATION	DESCRIPTION
WOODY	acceptable	Twenty samples have been analyzed, 60% of which have an 'acceptable' result. This is due to the fact that the Pilot LF layer detects small grassy and rocky patches and channel buffer strips with low geometric error; however, this corresponds to a semantic error since they are Grassy LF.
GRASSY	acceptable	Thirty-three samples have been analyzed, 45% of which are 'insufficient' due to commissions and omissions detected because they delimit grassy LF when in fact they correspond to areas of a reference parcel of arable land or pasture, or because they do not detect some small grassy and rocky patches. However, approximately 30% of the samples are 'good' and 20% 'acceptable' thanks mainly to the good geometric accuracy of the small grassy and rocky patches that it does detect. Therefore, it can be said that the elements that it does identify have good geometric accuracy.
WET	acceptable	Twelve samples have been analyzed, of which 50% have an 'insufficient' result due to commissions because it detects wet LF that in reality do not correspond to landscape elements because they are rivers or they are made of cement or plastic based. However, the other 50% have 'good' and 'acceptable' results by detecting the elements correctly as ponds.
STONY	poor	Twenty samples have been analyzed, of which approximately 100% have an 'insufficient' result. This is due to the high number of commissions and omissions due to the fact that it delimits buildings that are not landscape elements because they are not elements of traditional architecture, and because it does not delimit Stony LF such as terraces. There is not enough definition to recognize Stony LF.

Defined group	Commission	Semantic error	Correct	**Overall total**
Woody LF	2	16	2	**20**
excellent (1)		2	1	**3**
good (2)		1		**1**
acceptable (3)		11	1	**12**
poor (4)		2		**2**
insufficient (5)	2			**2**

Defined group	Commission	Omission	Correct	**Overall total**
Grassy LF	6	9	18	**33**
excellent (1)				**0**
good (2)			10	**10**
acceptable (3)			6	**6**
poor (4)			2	**2**
insufficient (5)	6	9		**15**

Defined group	Commission	Correct	Overall total
Wet LF	6	6	**12**
excellent (1)			
good (2)		4	**4**
acceptable (3)		2	**2**
poor (4)			
insufficient (5)	6		**6**

Defined group	Commission	Omission	Overall total
Stony LF	6	12	**18**
excellent (1)			**0**
good (2)			**0**
acceptable (3)			**0**
poor (4)			**0**
insufficient (5)	6	12	**18**

3.6. Conclusions

- **Technical conclusions**

The results offer a low parallelism between the automatically LF obtained from Pilot LF Layer and those LF available in the LPIS done by photointerpretation. This is motivated by two main reasons.

1) Automatic LF extraction process (object of this work):

- The used sources are those currently available, however, none of them has as its objective the specific identification of landscape elements, at the required level of detail for LF. Land scape features are secondary aspects or derived from the main objective of each data source.
- The non-existence of reliable sources for all LF target classes (for example Grassy or Stony landscape features)
- LF vectorial delimitation is automatically fuzzy using raster sources. Raster data (i.e. orthoimages, LiDAR, HRL and derived products) are the sources mainly proposed for this work, due to their high level of automation and productive performance. On the other hand, vector sources of information, which better delimit elements, entail, in most cases, a photo interpretation and human participation.
- The result is extremely sensitive to geometric selection criteria. They are not specifically agreed by the JRC for each country.

2) Origin of the differences between LF photointerpreted in the LPIS and the target LF classes proposed by the JRC. Both layers compared in the process, by nature present conceptual differences in their classes. This fact generates an insurmountable disparity in the results and must be known in its evaluation.

- LPIS LF only exist in declared parcels of arable land and permanent crops.
- Automatic LF according to JRC criteria can exist on any agricultural surface and its areas of influence (several meters of buffer), including pastures and undeclared parcels.
- The thematic classes of both sources are different and do not have a direct fit or gateway.
- LPIS LF may have absences.
- Related to Grassland and Improductive areas, these type of surfaces are included in the visual analysis and are mentioned in the description.

Visual comparison of the results and conclusion extractions takes these considerations into account, based in orthoimage and photointerpretation.

Considering the interoperability issues encountered and our ways of resolving them commented at the end of the point 3.2, and taking into account the technical considerations of the work and the result obtained, it can be affirmed that the automatic LF obtaining assists in the identification but does not replace their vectorial delimitation nor all its location. In order to achieve an automatic delimitation with good geometric precision of the LF, there should be more specific, automatable and higher resolution data sources, which do not yet exist at the national or continental level.

- **No technical conclusions**

The research project has represented a technical challenge for the experts involved, requiring knowledge and resources to explore and carry out new techniques not investigated until now by FEGA and IGN, so we consider that experience acquired previously in the experts career is an important value for this kind of projects.

The results of the project can be taken as a starting point for a more dedicated collaboration between both institutions and the JRC.

On the other hand, due to the nature of the research project, certain technical aspects in its development were not initially marked from the start, causing some uncertainty in its implementation. As it was explained in the mid-term review on February, due to problems detected during the works in the incomplete info in layers (for instance in LUCAS data), or administrative matters that impacted in the Spanish planification of the works, the first idea from Spain side was, related to the initial Sources of information, to do not consider the next sources from the Pilot LF Layer:

a) Sources where the geometries gives us the information of “existing LF”, but do not especify accurately the Type of LF; or

b) Sources where the geometries do not give us information about the presence/absence of LF.

That is, do not consider in our analysis those kind of geometries if Pilot LF Layer do not identify accurately an LF. With time, this decision was changed by developing different solutions and iterations that allowed us to increase our surface analysis capability (introducing firstly the codes 98 and 99, and secondly the codes 96 and 97), but also increased our workload. All this was done with a reasonable number of samples to analyze and check by photo-interpretation in our total 4 testing areas and thus obtain an adequate analysis of the pilot layer.

It is important to note that this project has been carried out mostly with national data sources, so the methodology followed cannot be implemented in other European countries. If the country has the same national information sources could be implemented.

Additionally to these difficulties and extra workload, another limitation has been the workload do not initially planned to develop the project, causing delays and added dedication. Initially estimated at 32 days of work from January to April (to be distributed among 4 “FEGA + IGN” experts), approximately a minimum of **96 days** of total work have been reached from January to July 2022.