Project IACS65

Czech Republic

FINAL REPORT

(Spatial Analysis)

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Content

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CZ	Czech Republic
ZABAGED	Czech topographic database
EEA	European Environment Agency
FMI	Forest Management Institute
LPIS	Land Parcel Identification System
LSO	Land Survey Office
LUCAS	Land Use/Cover Area Frame Survey
LF-EFA	Landscape EFA Features
LF	Landscape Features
LAU2	Local administrative unit
VKP	Significant Landscape Features
SLF	Small Landscape Features
SWF	Small Woody Features
OLIL	Wood Cover
RP	Reference Parcel

1 SPATIAL ANALYSIS AND PHOTOINTERPRETATION

The spatial analysis was primarily focused on the comparison between Landscape Features derived from a photointerpretation, and dataset of LF-EFAs generated from the LPIS database. This outcome was further compared with the third-party datasets, in order to derive to the conclusion, how useful these datasets might be for the LF-EFA dataset updating orextending.

1.1 Dataset LF-EFA and Third-party Datasets

The datasets used for the spatial analysis are defined in chapter 1.1. of the *"Interim report IACS_65_CZ_final"* created during the previous project phase (semantic analysis). Unfortunately, for the purpose of the spatial analysis the LUCAS dataset was not available, and the VKP datasets were available only for two test sites (see Table 1). Other datasets were available for all test areas (see Table 1).

Table 1. Datasets and number of test sites

Dataset	LF-EFA	VKP	VKP – specific ones	ZABAGED	OLIL	SWF	LUCAS
Number of test sites	9	1	1	9	9	9	0
Test sites	All	Výprachtice	Odry	All	All	All	None

1.2 Dataset from Photointerpretation

A new dataset of **Small Landscape Features** (SLF) was created based on a photointerpretation for the selected 9 pilot sites (see Chapter 1.2) *"Interim report IACS_65_CZ_final"*. Vectorisation was made using open-source Geographic Information System QGIS 3. Individual vectorisation projects were created separately for each test site. Vectorisation projects were made in S-JTSK (Krovak East-North), the CZ national geodetic coordinate system (EPSG: 5514).

1.2.1 Layers in Vectorisation project

During the spatial analysis, only Landscape Features (LF) that were located inside a Reference Parcel or at the borderline or adjacent, and at the same time were located within the test areas (LAU2) were examined. The Landscape Features that were identified through the photointerpretation process were stored in a new dataset called **Small Landscape Feature (SLF).** For the SLF dataset vectorisation, pre-defined attributes were prepared by the team of operators in advance.

Likewise, the layer of **Reference Parcels** (Farmer's blocks) from the LPIS database was added into the vectorisation project as a source layer of the agricultural land.

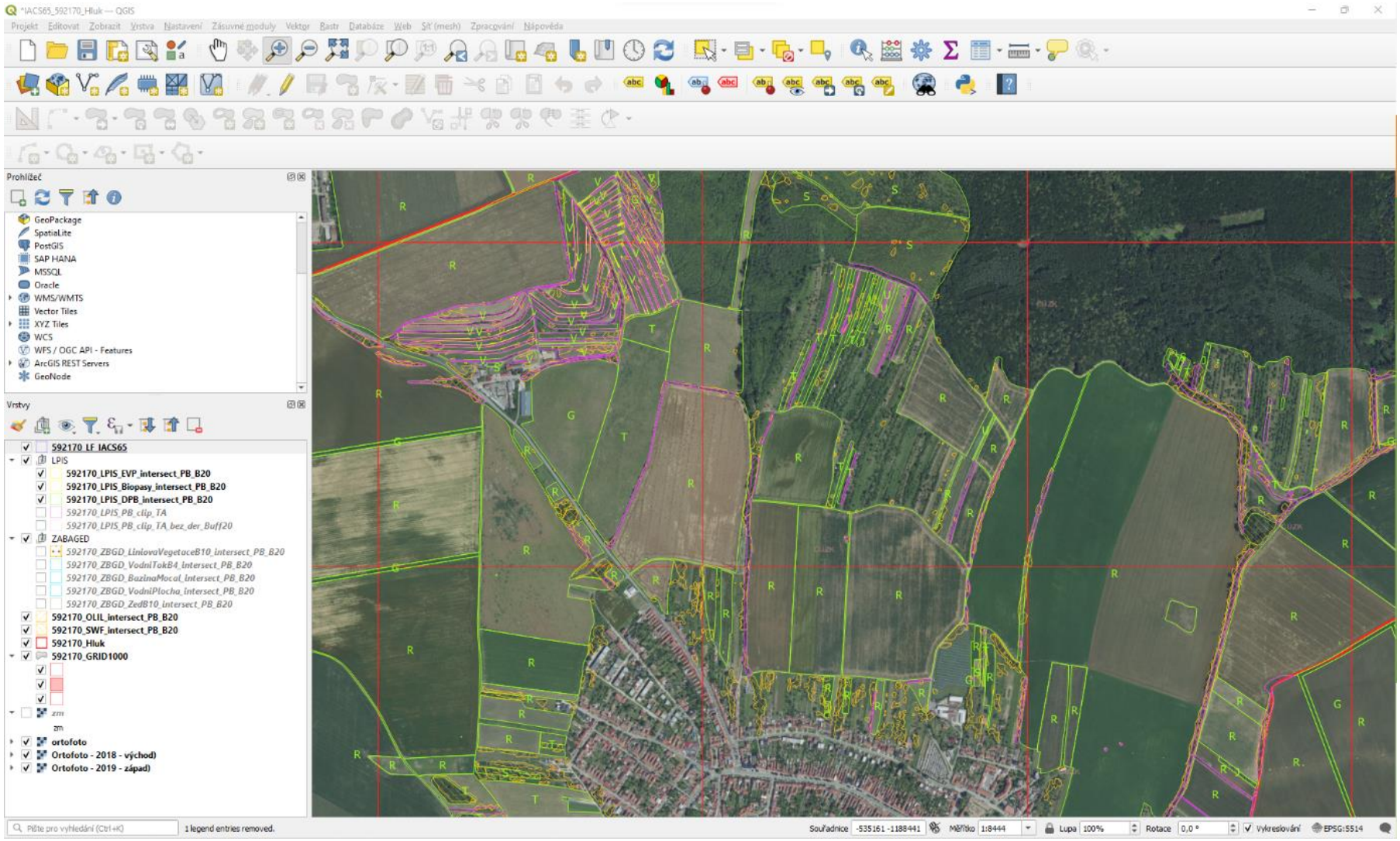
Another important layer was represented by **Orthorectified images**, based on data from the Land Survey Office (LSO). The up-to date orthoimagery from years 2020/2021 were used to the maximum extent. However, in certain situations the older orthoimagery from years 2018/2019 and 2016/2017 were used, too. Mainly for areas along forests, where presence of shadow was/is quite common or in situations when up-to date orthoimagery was taken quite early in the year. Hence, the specific vegetation (e.g. broadleaf trees) could not be easily recognisable.

The **Dataset LF-EFA** from LPIS was used too, as a supporting layer in the vectorisation project. The dataset LF-EFA contains Woody Features (Isolated trees, Tree lines and avenues, Hedges, Trees in group), Grassy Features (Bio-belts, Buffer strips, Grassed thalwegs), Wet Features (Small wetlands, Ditches) and Stony Features (Terraces). Landscaping orchard; Fast-growing woody plants and Afforested land are also elements of LF-EFA dataset. However, such feature types are quite large and their area is often bigger than 0.5 hectares. Hence, according to the methodology of this project, such elements were excluded from the original LF-EFA dataset.

Other third-party datasets were used as supporting layers in the vectorisation project, too. For example: **ZABAGED** dataset from LSO; **OLIL** dataset from Forest Management Institute (FMI) and **SWF** dataset from European Environment Agency (EEA). The ZABAGED dataset contains Woody Features (Isolated trees, Tree in groups, Line vegetation), Wet Features (Watercourse flow, Small wetlands, Water Body) and Stony Features (Walls, Rock outcrops, Stacks of Stones). The other two datasets OLIL and SWF contain only Woody Features, and they are not further subdivided into the feature classes. The existing LFs from the third-party dataset (ZABAGED, OLIL, SWF) and dataset LF-EFA were displayed as source data in the vectorisation project, covering LFs that are located inside the Reference Parcel, directly adjacent or in 20 m buffer zone around the Reference Parcel.

In order to follow the systematic approach, the LFs were processed sequentially in 1 x 1 km grids (see Image 1).

Image 1. Example of layers in vectorisation project and grid system



2 METHODOLOGY

2.1 Photointerpretation

Dataset of **Small Landscape Features** (SLF) was created by manual vectorisation of Landscape Features (LF) using the most recent available orthoimagery map. The vectorisation project was created by the team of three operators.

In general, the map scale used for the vectorisation was 1 : 800. However, some Landscape Features like Isolated trees or Stacks of Stones were vectorised in 1 : 400 map scale due to their small size. In order to follow the systematic approach, the Landscape Features were processed sequentially in 1 x 1 km grids. The following attributes were pre-defined in the selection menu of the Small Landscape Features layer:

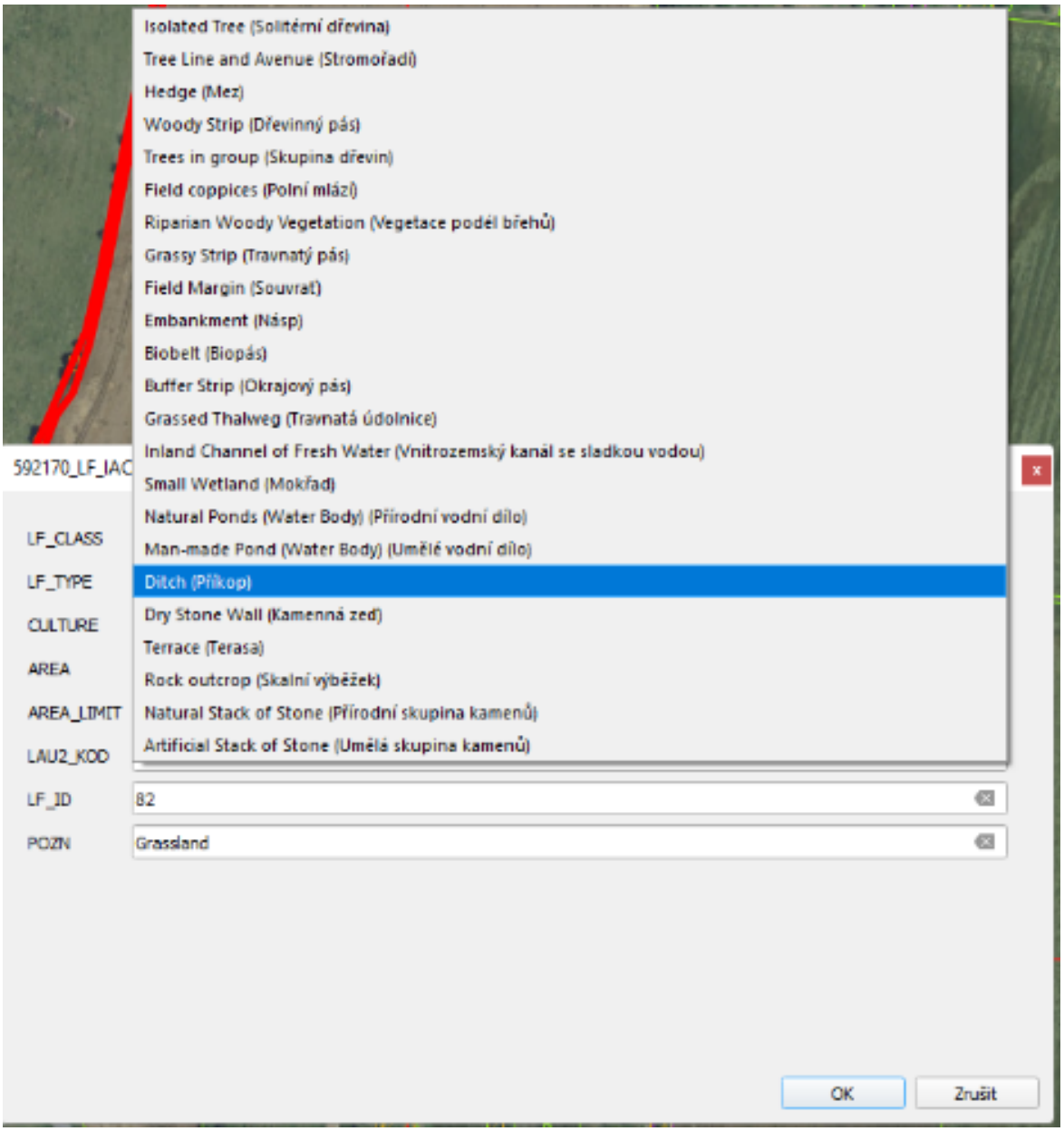
Landscape Feature class (Woody, Grassy, Wet, Stony Features),

Landscape Feature type (Isolated trees, Tree lines and avenues, Hedges, Woody strips, Trees in group, Field Coppices, Riparian woody vegetation, Grassy strips, Field Margins, Embankments, Bio-belts, Buffer strips, Grassed thalweg, Inland Channels of Fresh Water, Small wetlands, Standing Small Water Bodies such as natural ponds, Standing Small Water Bodies such as Man-made ponds, Ditches, Dry stone walls, Terraces, Rock outcrops, Natural Stacks of Stone, Artificial Stacks of Stone; (see Image 2)),

Agricultural type (Arable land, Grassland and Permanent Cropland).

The main attributes, from the selection menu were filled-in by the operators as a result of the vectorisation process. The other attributes of SLF layer were either calculated automatically (Area in square meters) or automatically filled in, based on the LAU 2 code.

Image 2. ***Example of Landscape Feature type in the selection menu***



For the purpose of the project, the core rules of vectorisation process were agreed among the team of operators, in advance. Such as the rule, that trees are vectorised by the borders of their tree crowns, not by their trunks (see Image 3).

Image 3. ***Example of vectorisation of Isolated trees according to the border of their tree crowns***

In order to maintain unified types of objects and taking into account that polygons are more suitable for spatial analysis, the watercourses were vectorised as polygons (see Image 4).

Image 4. ***Example of the vectorisation of Watercourse as a polygon***

Hedges were delineated by the borderline of their grassy parts, not following the borderline of their woody or stony parts, since it was assumed that Grassy Features are parts of the Hedge elements. Example can be seen in the Image 5.

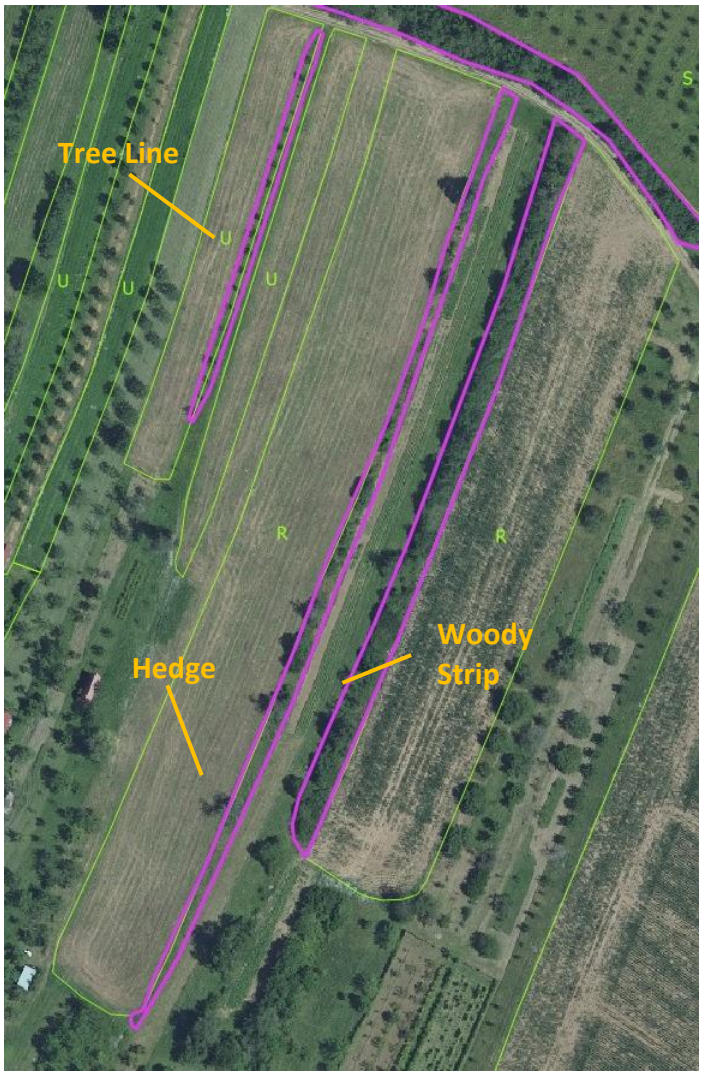
Image 5. Example of large Hedge formed by Bushes, Trees in group and Grassy part

The Isolated trees and Trees in group on Permanent Cropland were not vectorised during the spatial analysis, since these are usually used as productive trees. Hence, were not interpreted by operators as a non-productive LFs (see Image 6).

Image 6. Example of Permanent Cropland – LF not vectorised

For the purpose of the vectorisation process, further rules were stipulated regarding differentiation between Tree lines and Avenues, Hedges, Woody strips and Riparian woody vegetation. In particular, trees in Tree lines and Avenues should be present in one row and individual tree crowns should be visible as separate objects. While Woody strips can have multiple rows of trees and the crowns of the individual trees might be clustered. Whereas, Hedges could contain not only trees, but also grass and shrubs vegetation (see Image 7).

Image 7. Examples of Tree lines and avenues, Hedges and Woody strips



The vectorisation rules for the Riparian woody vegetation were defined as follows. When the Small watercourse exists in dataset ZABAGED, and at the same location some trees are present, then the features is classified as Riparian woody vegetation (see Image 8).

Image 8. Example of the Riparian woody vegetation

After completion of vectorisation process by an individual operator, the test areas were swopped and created datasets were checked by another operator, following the four-eyes principle.

2.2 Spatial Analysis

The Spatial Analysis was made in an open-source geographical information system QGIS 3 and table processor MS Excel.

For the spatial analysis, LFs from third party datasets, LF-EFA dataset and dataset from photointerpretation were selected by location of the pilot areas. Only LFs that fit with **three main criteria** (LFs inside agricultural land; LFs inside buffer zone 20 meters adjacent to the agricultural land; and LFs on the borderline of agricultural land) were used as an input for the spatial analysis. Agricultural land was represented by the LPIS reference parcel (Farmer's block). However, the LPIS reference parcel could contain holes, where LFs could be theoretically present. Hence, during the spatial analysis, these holes were aggregated to the reference polygons. This step was important for the categorisation of LFs into one of the above stated groups.

Following the project rules (see Table 1 of the document *"Interoperability case study for landscape features and preparation of input materials for the IACS-INSPIRE interoperability technical guidelines"*) LFs bigger than 0.5 ha were filtered out. Consequently, 238 features bigger than 0.5 ha were deleted from the dataset of SLF, 27 from dataset LF-EFA, 78 from dataset OLIL, 1 079 from dataset ZABAGED and 155 from dataset VKP (Table 2).

Table 2. Number of LFs bigger than 0.5 ha

Dataset	Number of LFs bigger than 0.5 ha
SLF	238
LF-EFA	27
OLIL	78
ZABAGED	1 079
VKP	155
SWF	695

The LFs that lay outside the selected pilot areas were also removed from the datasets (see Table 3).

Table 3. Number of LFs outside the test areas

Dataset	Number of LFs outside the test areas
SLF	17
LF-EFA	30
OLIL	163
ZABAGED	43
VKP	665
SWF	0

The spatial analysis was divided in two main phases. The first phase was represented by a descriptive analysis of all datasets (SLF, LF-EFA, ZABAGED, OLIL, VKP, SWF). The second phase was represented by a comparative analysis.

Descriptive statistics summarises LFs according to the three main criteria (LFs inside Agricultural Land; LFs inside buffer zone 20 meters adjacent to the Agricultural Land; and LFs on the borderline of Agricultural Land), and also according to the type of agricultural land, and pilot areas.

The goal of comparative statistics was to identify, to what extent the third-party datasets are useful for the LF-EFA dataset updating and extending. **The dataset SLF was used as a reference dataset to reflect the actual situation of the Landscape Features**. The LFs were assessed according to the following decision tree (Table 4), in respect of their usability for the LF-EFA dataset updating.

Table 4. Decision tree for using third party datasets

Situations:	SLF	LF-EFA	OLIL/VKP/ZABAGED	Attributes	Result
1.	Yes	Yes	x	same	nothing
2.	Yes	Yes	x	different	indication to change of attributes
3.	Yes	No	Yes	same	add to LF-EFA
4.	Yes	No	Yes	different	add to LF-EFA (expert judgement/rapid field visit/GT photo)
5.	Yes	No	No	x	add to LF-EFA (dataset of third party not available)
6.	No	x	Yes	x	do not add to LF-EFA (does not represent the LF)
7.	No	Yes	x	x	Further verification (terrain visit recommended, GT photo, etc.)

Firstly, the spatial join function between SLF and LF-EFA datasets was applied. Then the LFs that are present in SLF dataset, but at the same time are not present in LF-EFA were examined. These LFs are indicated for admission to the LF-EFA (labelled as ADD LF-EFA; Table 4).

In further step, the LFs that are present in both datasets (SLF and LF-EFA) were examined. For these, the value of attributes of Landscape Feature class (LF class) and Landscape Feature type (LF type) were compared between SLF and LF-EFA datasets.

Then, the function spatial join was applied on "Add LF-EFA" dataset and the third-party datasets (ZABAGED, OLIL, VKP, SWF). During this step, specific LFs from third party datasets were identified in respect to their suitability to be added into the LF-EFA dataset.

3 RESULTS

3.1 Process of photointerpretation

The photointerpretation process was implemented by the team of three operators/experts. Each operator processed three test areas, which correspond to approximately 14 720 hectares of land (of which 5 918 hectares of agricultural land registered in the LPIS) per operator. In total, 44 163 hectares of land (17 756 hectares of agricultural land registered in LPIS) was surveyed.

The processing speed of 17 756 hectares was approximately 75 mapped hectares of agricultural land per hour. By this consideration it would take about 47 337 hours to map all registered agricultural land in the LPIS, which would be 5 917 man days, for the whole area of the Czech Republic, if vectorisation would be done manually and from the scratch. However, two important things should be reflected. Firstly, within this project the vectorised test areas have been selected due to their high volumes of presence of LFs. Secondly, the potential future vectorisation of the whole area of CZ would not be made from the scratch, since huge percentage of Small Landscape Features are already vectorised in the LF-EFA dataset (LPIS database) and in datasets of third parties, too.

3.2 Descriptive statistical analysis

3.2.1 SLF

Dataset of Small Landscape Features (SLF) is a result of the photointerpretation process. The most common LF class is represented by Woody feature (12 515 LFs). The second most common class is represented by Stony Feature (486 LFs). While the least frequent LF class is represented by Grassy feature (11 LFs) (Table 5).

It is assumed, that these results are influenced by the applied photointerpretation method, since the Woody Feature is the most visible in the orthoimagery. Whereas, Grassy Feature may be easily confused with the Agricultural Land (in particular with the permanent grassland), and the Stony Feature can be located under the tree crowns. Hence, they might not be easily visible in the orthoimagery.

The location of the LF was also investigated, respectively whether the LF is situated within the reference parcel, on their borderline, or is adjacent to the reference parcel within 20 m buffer; (see **Chyba! Nenalezen zdroj odkazů.**). Some Landscape Features are typically the borderline types (such as Inland channel of fresh water, Bio-belt, Terrace, Riparian woody vegetation), while others are typically inner ones (such as Natural stack of stone, Isolated tree). Trees in group is a type of Landscape Feature, that is usually present inside the reference parcel, as well as on the borderline. The amount of identified adjacent LF types is not significant (see **Chyba! Nenalezen zdroj odkazů.**).

Table 5. Number of Small Landscape Features (SLF) according to their spatial relationship with Reference Parcel

Landscape Feature Class and Type	Adjacent to RP	Borderline of RP	Inside of RP	In Total	In % of Total
Grassy Feature		**9**	**2**	**11**	**0.1 %**
Bio-belt		4		4	36.4 %
Embankment		3		3	27.3 %
Grassed thalweg		1	1	2	18.2 %
Grassy strip		1	1	2	18.2 %
Stony Feature	**5**	**52**	**429**	**486**	**3.7 %**
Artificial stack of stone		2	2	4	0.8 %
Dry stone wall		2	1	3	0.6 %
Natural stack of stone	1	8	426	435	89.5 %
Terrace	4	40		44	9.1 %
Wet Feature	**4**	**159**	**81**	**244**	**1.8 %**
Ditch		25	8	33	13.5 %
Inland channel of fresh water		60		60	24.6 %
Man-made pond (Water body)		16	3	19	7.8 %
Natural Ponds (Water body)	4	3	5	12	4.9 %
Small wetland		55	65	120	49.2 %
Woody Feature	**452**	**6 376**	**5 687**	**12 515**	**94.4 %**
Hedge	7	913	362	1 282	10.2 %
Isolated tree	275	1 664	2 983	4 922	39.3 %
Riparian woody vegetation	14	434	6	454	3.6 %
Tree line and avenue	6	525	60	591	4.7 %
Trees in group	119	2 355	2 221	4 695	37.5 %
Woody strip	31	485	55	571	4.6 %
In Total	**461**	**6 596**	**6 199**	**13 256**	**100.0 %**
In % of Total	**3.5 %**	**49.8 %**	**46.8 %**	**100.0 %**	-

In this analysis, the Permanent Cropland type achieved the lowest level of presence of Landscape Features (only 53 LFs). Contrary, the highest number of Landscape Features (10 114 LF) was achieved on Grassland.

Number of Landscape Feature types of SLF are shown in Table 6. The Stony Feature category is equally represented on Arable Land and on Grassland (see Table 6). Woody Features and Wet Features are more common for Grassland land use type. It is assumed, that this is mainly due to the location of grassland. The Grasslands are usually located at higher altitudes, which are characterised by greater overall forest cover, and are often the source of watercourses, in the Czech Republic.

Table 6. Number of Small Landscape Features (SLF) according to type of Agricultural land

Landscape Feature Class and Type	Adjacent to RP	Arable Land	Grassland	Permanent Cropland	In Total	In % of Total
Grassy Feature		**9**	**2**		**11**	**0.1 %**
Bio-belt		4			4	36.4 %
Embankment		3			3	27.3 %
Grassed thalweg			2		2	18.2 %
Grassy strip		2			2	18.2 %
Stony Feature	**5**	**246**	**203**	**32**	**486**	**3.7 %**
Artificial stack of stone		1	3		4	0.8 %
Dry stone wall			3		3	0.6 %
Natural stack of stone	1	244	190		435	89.5 %
Terrace	4	1	7	32	44	9.1 %
Wet Feature	**4**	**34**	**205**	**1**	**244**	**1.8 %**
Ditch		6	27		33	13.5 %
Inland channel of fresh water		14	45	1	60	24.6 %
Man-made pond (Water body)		2	17		19	7.8 %
Natural Ponds (Water body)	4		8		12	4.9 %
Small wetland		12	108		120	49.2 %
Woody Feature	**452**	**2 339**	**9 704**	**20**	**12 515**	**94.4 %**
Hedge	7	442	827	6	1 282	10.2 %
Isolated tree	275	585	4 061	1	4 922	39.3 %
Riparian woody vegetation	14	177	261	2	454	3.6 %
Tree line and avenue	6	220	365		591	4.7 %
Trees in group	119	802	3 767	7	4 695	37.5 %
Woody strip	31	113	423	4	571	4.6 %
In Total	**461**	**2 628**	**10 114**	**53**	**13 256**	**100.0 %**
In % of Total	**3.5 %**	**19.8 %**	**76.3 %**	**0.4 %**	**100.0 %**	**-**

The lowest number of Landscape Features are in regions with the dominance of Arable Land (Budyně nad Ohří, Hluk). While the highest volumes of Landscape Features are reached in mountain regions with dominance of Grassland (Čachrov, Nový Hrozenkov) (see Chapter 1.2 of *"Interim report_IACS_65_CZ_final"*). Hilly region (Březová) contains also many Landscape Features (1 273 LF). Výprachtice is hilly region same as Březová, but this region has higher portion of Arable Land, hence the number of Landscape Features is lower (628 LF). In regions Kovářov and Milevsko, there are the highest numbers of Stony Features (approx. 200 objects). Detailed numbers of presence of individual types of Landscape Features in the test areas are shown in Table 7.

Table 7. Number of Small Landscape Features (SLF) according to Test Areas

Landscape Feature Class and Type	560294 Březová	564656 Budyně nad Ohří	555941 Čachrov	592170 Hluk	549517 Kovářov	549576 Milevsko	544566 Nový Hrozenkov	599701 Odry	581178 Výprachtice	In Total	In % of Total
Grassy Feature		**3**			**4**	**3**			**1**	**11**	**0.1 %**
Bio-belt					4					4	36.4 %
Embankment		3								3	27.3 %
Grassed thalweg						1			1	2	18.2 %
Grassy strip						2				2	18.2 %
Stony Feature	**33**	**1**		**36**	**212**	**193**	**11**			**486**	**3.7 %**
Artificial stack of stone	1				2	1				4	0.8 %
Dry stone wall						1	2			3	0.6 %
Natural stack of stone	32				210	191	2			435	89.5 %
Terrace		1		36			7			44	9.1 %
Wet Feature	**118**		**9**	**3**	**57**	**40**	**4**	**11**	**2**	**244**	**1.8 %**
Ditch	9		5	1	4	2	4	6	2	33	13.5 %
Inland channel of fresh water	17			1	13	29				60	24.6 %
Man-made pond (Water body)	1				14	4				19	7.8 %
Natural Ponds (Water body)			4			3		5		12	4.9 %
Small wetland	91			1	26	2				120	49.2 %
Woody Feature	**1 122**	**436**	**3 616**	**328**	**1 881**	**1 563**	**1 901**	**1 043**	**625**	**12 515**	**94.4 %**
Hedge	45	168	147	46	240	222	228	115	71	1 282	10.2 %
Isolated tree	462	64	1 817	124	490	351	843	498	273	4 922	39.3 %
Riparian woody vegetation	40	45	29	32	129	120	29	20	10	454	3.6 %
Tree line and avenue	104	39	3	32	148	159	97	9		591	4.7 %
Trees in group	471	92	1 463	70	871	706	543	289	190	4 695	37.5 %
Woody strip		28	157	24	3	5	161	112	81	571	4.6 %
In Total	**1 273**	**440**	**3 625**	**367**	**2 154**	**1 799**	**1 916**	**1 054**	**628**	**13 256**	**100.0 %**
In % of Total	**9.6 %**	**3.3 %**	**27.3 %**	**2.8 %**	**16.2 %**	**13.6 %**	**14.5 %**	**8.0 %**	**4.7 %**	**100.0 %**	**-**

3.2.2 LF-EFA

LF-EFA dataset has less Landscape Feature types than SLF dataset (see Table 5 and Table 8). For example, in the LF-EFA dataset the Embankment, Artificial or Natural stack of stone, Ditch, Riparian woody vegetation or Woody strips don´t exist. On the other hand, LF-EFA dataset contains more Grassy Features than dataset SLF (see Table 5 and Table 8).

Woody feature dataset holds high number of Landscape Features, for the same reason as SLF dataset (see Chapter 3.2.1). The most frequent Landscape Feature types are Trees in group and

Isolated tree. They typically represent inner type of Landscape Feature. On the other hand, the Terrace is typically borderline type of Landscape Feature (see Table 8).

Table 8. Number of LF-EFA Features according to spatial relationship with Reference Parcel

Landscape Feature Class and Type	Adjacent to RP	Borderline of RP	Inside of RP	In Total	In % of Total
Grassy Feature		**3**	**11**	**14**	**0.3 %**
Bio-belt			8	8	57.1 %
Travnatá údolnice		3	3	6	42.9 %
Stony Feature		**23**	**1**	**24**	**0.6 %**
Terasa		23	1	24	100.0 %
Wet Feature		**1**	**30**	**31**	**0.8 %**
Mokřad		1	30	31	100.0 %
Woody Feature	**63**	**188**	**3 710**	**3 961**	**98.3 %**
Mez	5	40	300	345	8.7 %
Skupina dřevin	25	120	1 734	1 879	47.4 %
Solitérní dřevina	32	22	1 619	1 673	42.2 %
Stromořadí	1	6	57	64	1.6 %
In Total	**63**	**215**	**3 752**	**4 030**	**100.0 %**
In % of Total	**1.6 %**	**5.3 %**	**93.1 %**	**100.0 %**	**-**

Permanent Cropland has the lowest occurrence of Landscape Features (see Table 9). It is assumed, that the reason for that is a combination of presence of Woody Features in productive form, and hence they are not assessed as LFs. The most frequent Landscape Feature class is represented by Woody feature that grow primarily on Grassland areas.

Table 9. Number of LF-EFA Features according to type of Agricultural land

Landscape Feature Class and Type	Adjacent to RP	Arable Land	Grassland	Permanent Cropland	In Total	In % of Total
Grassy Feature		**8**	**6**		**14**	**0.3 %**
Bio-belt		7	1		8	57.1 %
Travnatá údolnice		1	5		6	42.9 %
Stony Feature		**1**		**23**	**24**	**0.6 %**
Terasa		1		23	24	100.0 %
Wet Feature			**31**		**31**	**0.8 %**
Mokřad			31		31	100.0 %
Woody Feature	**63**	**344**	**3 532**	**22**	**3 961**	**98.3 %**
Mez	5	49	288	3	345	8.7 %
Skupina dřevin	25	222	1 626	6	1 879	47.4 %
Solitérní dřevina	32	69	1 561	11	1 673	42.2 %
Stromořadí	1	4	57	2	64	1.6 %
In Total	**63**	**353**	**3 569**	**45**	**4 030**	**100.0 %**
In % of Total	**1.6 %**	**8.8 %**	**88.6 %**	**1.1 %**	**100.0 %**	-

The LF-EFA dataset has the similar trend as the SLF dataset. The most frequent Landscape Features are located in mountain regions (Nový Hrozenkov, Čachrov). The lowest volumes of Landscape Features were reached in pilot areas with pre-dominant Arable Land use type (Budyně nad Ohří, Hluk). The pilot region Hluk reached the highest number of Stony Features, because there are plenty of Terraces, which are linked to Permanent Cropland (primarily Vineyards). The pilot region Hluk was selected for this study (see Chapter 1.2 of the *"Interim report_IACS_65_CZ_final"*), since it is an area of the highest number of Terraces in LF-EFA dataset. The highest number of Wet Features has been indicated in region Březová. This region was also selected for the study, due to its high volumes of Small wetlands in the LF-EFA dataset.

Table 10. Number of LF-EFA Features according to Test Areas

Landscape Feature Class and Type	560294 Březová	564656 Budyně nad Ohří	555941 Čachrov	592170 Hluk	549517 Kovářov	549576 Milevsko	544566 Nový Hrozenkov	599701 Odry	581178 Výprachtice	In Total	In % of Total
Grassy Feature					**9**	**2**			**3**	**14**	**0.3 %**
Bio-belt					8					8	57.1 %
Travnatá údolnice					1	2			3	6	42.9 %
Stony Feature				**23**		**1**				**24**	**0.6 %**
Terasa				23		1				24	100.0 %
Wet Feature	**30**						**1**			**31**	**0.8 %**
Mokřad	30						1			31	100.0 %
Woody Feature	**174**	**25**	**963**	**54**	**536**	**528**	**1 388**	**110**	**183**	**3 961**	**98.3 %**
Mez	10	17	32	4	29	32	185	25	11	345	8.7 %
Skupina dřevin	86	5	662	7	343	278	375	57	66	1 879	47.4 %
Solitérní dřevina	78	2	268	41	162	215	776	25	106	1 673	42.2 %
Stromořadí		1	1	2	2	3	52	3		64	1.6 %
In Total	**204**	**25**	**963**	**77**	**545**	**531**	**1 389**	**110**	**186**	**4 030**	**100.0 %**
In % of Total	**5.1 %**	**0.6 %**	**23.9 %**	**1.9 %**	**13.5 %**	**13.2 %**	**34.5 %**	**2.7 %**	**4.6 %**	**100.0 %**	-

3.2.3 OLIL

The dataset OLIL contains only Woody Features. The number of Woody Features is higher in this dataset than in the LF-EFA dataset, but lower than in the SLF dataset. The OLIL dataset has only three sub-categories of Landscape Feature types – Linear type of Woody Features, Trees in group and Isolated trees. In total, most of the Landscape Feature classes are on the borderline of the Reference Parcel. The most frequent Landscape Feature type is Isolated tree (OLIL 500; see Table 11), that account for 87.5 % of all features registered in the OLIL dataset see Table 11. The borderline LF types are well represented in the OLIL dataset (see Table 11). This fact is probably due to the method of data collection for the purpose of the OLIL database (see Chapter 1.1 of the *"Interim report_IACS_65_CZ_final").*

Table 11. Number of OLIL Features according to spatial relationship with Reference Parcel

Landscape Feature Class and Type	Adjacent to RP	Borderline of RP	Inside of RP	In Total	In % of Total
Woody Feature	**3 404**	**8 342**	**3 101**	**14 847**	**100.0 %**
OLIL 300 - Liniové porosty dřevin	132	1 093	90	1 315	8.9 %
OLIL 400 - Malé plošné porosty dřevin	67	415	61	543	3.7 %
OLIL 500 - Solitérní stromy a hloučky dřevin	3 205	6 834	2 950	12 989	87.5 %
In Total	**3 404**	**8 342**	**3 101**	**14 847**	**100.0 %**
In % of Total	**22.9 %**	**56.2 %**	**20.9 %**	**100.0 %**	-

Most of the Woody Features registered in the OLIL dataset are located on the Grassland (see Table 12). The lowest occurrence of Woody Features is on the Permanent Cropland. However, the frequency is relatively high with comparison to the LF-EFA and SLF datasets (see Table 6, Table 9 a Table 12). The Isolated tree on Grasslands is the most frequent LF type (8 271 LF) in the OLIL dataset.

Table 12. Number of OLIL Features according to type of Agricultural land

Landscape Feature Class and Type	Adjacent to RP	Arable Land	Grassland	Permanent Cropland	In Total	In % of Total
Woody Feature	**3 404**	**2 822**	**8 271**	**350**	**14 847**	**100.0 %**
OLIL 300 - Liniové porosty dřevin	132	457	715	11	1 315	8.9 %
OLIL 400 - Malé plošné porosty dřevin	67	122	337	17	543	3.7 %
OLIL 500 - Solitérní stromy a hloučky dřevin	3 205	2 243	7 219	322	12 989	87.5 %
In Total	**3 404**	**2 822**	**8 271**	**350**	**14 847**	**100.0 %**
In % of Total	**22.9 %**	**19.0 %**	**55.7 %**	**2.4 %**	**100.0 %**	-

Most of the LFs are located in mountain and hilly regions (Čachrov, Kovářov, Milevsko, Nový Hrozenkov, Odry) with pre-dominance of Grassland land use category and Forests (see Table 13). Quite frequent in these regions are also Isolated trees.

Table 13. Number of OLIL Features according to the Test Areas

Landscape Feature Class and Type	560294 Březová	564656 Budyně nad Ohří	555941 Čachrov	592170 Hluk	549517 Kovářov	549576 Milevsko	544566 Nový Hrozenkov	599701 Odry	581178 Výprachtice	In Total	In % of Total
Woody Feature	**1 101**	**1 021**	**2 446**	**834**	**2 614**	**2 068**	**2 179**	**1 678**	**906**	**14 847**	**100.0 %**
OLIL 300 - Liniové porosty dřevin	65	149	156	107	235	184	133	180	106	1 315	8.9 %
OLIL 400 - Malé plošné porosty dřevin	23	32	50	14	135	100	84	68	37	543	3.7 %
OLIL 500 - Solitérní stromy a hloučky dřevin	1 013	840	2 240	713	2 244	1 784	1 962	1 430	763	12 989	87.5 %
In Total	**1 101**	**1 021**	**2 446**	**834**	**2 614**	**2 068**	**2 179**	**1 678**	**906**	**14 847**	**100.0 %**
In % of Total	**7.4 %**	**6.9 %**	**16.5 %**	**5.6 %**	**17.6 %**	**13.9 %**	**14.7 %**	**11.3 %**	**6.1 %**	**100.0 %**	-

3.2.4 ZABAGED

ZABAGED dataset is created in 1 : 10 000 scale. Very likely, due to that the lower number of Landscape Features (3 826 LF, see Table 14) are present in this dataset. The dataset contains three Landscape Feature classes: Stony Features, Wet Features and Woody Features. Stony Features are more present inside the Reference Parcels (see Table 14), while other Landscape Feature classes (Wet and Woody Features) are more often on the borderline or adjacent to the reference parcel (see Table 14).

Stony and Wet Features are equally represented Landscape Features (approx. 500 LF). The most frequent ones are Stacks of stones (Stony Feature) and Inland channels of fresh waters (Wet Feature).

Table 14. Number of ZABAGED Features according to spatial relationship with Reference Parcel

Landscape Feature Class and Type	Adjacent to RP	Borderline of RP	Inside of RP	In Total	In % of Total
Stony Feature	**229**	**186**	**338**	**753**	**19.7 %**
balvan, skála	1	2	9	12	1.6 %
mohyla, pomník, náhrobek	2	4		6	0.8 %
skupina balvanů	204	161	328	693	92.0 %
zeď	22	19	1	42	5.6 %
Wet Feature	**660**	**504**	**42**	**1 206**	**31.5 %**
bažina, močál	23	21	2	46	3.8 %
vodní plocha	191	5	16	212	17.6 %
vodní tok	446	478	24	948	78.6 %
Woody Feature	**180**	**1 243**	**444**	**1 867**	**48.8 %**
osamělý lesík	61	42	158	261	14.0 %
osamělý strom	30	91	235	356	19.1 %
stromořadí	89	1 110	51	1 250	67.0 %
In Total	**1 069**	**1 933**	**824**	**3 826**	**100.0 %**
In % of Total	**27.9 %**	**50.5 %**	**21.5 %**	**100.0 %**	**-**

In the ZABAGED, Landscape Features are present mainly on Grassland (see Table 15), while lowest numbers are achieved on Permanent Cropland.

Table 15. Number of ZABAGED Features according to type of Agricultural land

Landscape Feature Class and Type	Adjacent to RP	Arable Land	Grassland	Permanent Cropland	In Total	In % of Total
Stony Feature	**229**	**174**	**349**	**1**	**753**	**19.7 %**
balvan, skála	1	4	7		12	1.6 %
mohyla, pomník, náhrobek	2	1	3		6	0.8 %
skupina balvanů	204	163	325	1	693	92.0 %
zeď	22	6	14		42	5.6 %
Wet Feature	**660**	**112**	**423**	**11**	**1 206**	**31.5 %**
bažina, močál	23		23		46	3.8 %
vodní plocha	191	5	16		212	17.6 %
vodní tok	446	107	384	11	948	78.6 %
Woody Feature	**180**	**376**	**1 305**	**6**	**1 867**	**48.8 %**
osamělý lesík	61	37	163		261	14.0 %
osamělý strom	30	86	240		356	19.1 %
stromořadí	89	253	902	6	1 250	67.0 %
In Total	**1 069**	**662**	**2 077**	**18**	**3 826**	**100.0 %**
In % of Total	**27.9 %**	**17.3 %**	**54.3 %**	**0.5 %**	**100.0 %**	**-**

Most of the Landscape Features are found in the pilot regions located in the south of the Czech Republic (Čachrov, Kovářov, Milevsko; see Table 16). It is assumed that the reason for the concentration of Landscape Features in some locations is caused by different approach of regional office of Land Survey Office. Most likely, these numbers also include LFs generated due to errors that occurred during the initial creation of the ZABAGED dataset (Lysák, 2015). Pilot regions Milevsko and Kovářov were selected for this study due to the high numbers of Stony Landscape Features registered in the ZABAGED dataset (see Chapter 1.2 of the *"Interim report_IACS_65_CZ_final"*).

Table 16. Number of ZABAGED Features according to Test Areas

Landscape Feature Class and Type	560294	564656	555941	592170	549517	549576	544566	599701	581178	In Total	In % of Total
	Březová	Budyně nad Ohří	Čachrov	Hluk	Kovářov	Milevsko	Nový Hrozenkov	Odry	Výprachtice		
Stony Feature	**8**	**15**	**38**	**1**	**361**	**229**	**57**	**9**	**35**	**753**	**19.7 %**
balvan, skála	3	1			8					12	1.6 %
mohyla, pomník, náhrobek	1		1		4					6	0.8 %
skupina balvanů	3	10	32		338	229	46	3	32	693	92.0 %
zeď	1	4	5	1	11		11	6	3	42	5.6 %
Wet Feature	**152**	**76**	**280**	**34**	**198**	**169**	**118**	**130**	**49**	**1 206**	**31.5 %**
bažina, močál	28	2	7	1	3	2			3	46	3.8 %
vodní plocha	27	6	34	3	56	44	10	28	4	212	17.6 %
vodní tok	97	68	239	30	139	123	108	102	42	948	78.6 %
Woody Feature	**207**	**80**	**510**	**27**	**299**	**316**	**175**	**171**	**82**	**1 867**	**48.8 %**
osamělý lesík	45	3	61		72	55	4	9	12	261	14.0 %
osamělý strom	64		105		63	77	9	31	7	356	19.1 %
stromořadí	98	77	344	27	164	184	162	131	63	1 250	67.0 %
In Total	**367**	**171**	**828**	**62**	**858**	**714**	**350**	**310**	**166**	**3 826**	**100.0 %**
In % of Total	**9.6 %**	**4.5 %**	**21.6 %**	**1.6 %**	**22.4 %**	**18.7 %**	**9.1 %**	**8.1 %**	**4.3 %**	**100.0 %**	**-**

3.2.5 VKP

There are no specific rules stipulated for the VKP Landscape Feature dataset regarding the dataset creation, data gathering, etc. This dataset contains only 192 Landscape Features. Most of the Landscape Features (117 LF) are on the borderline of the Reference Parcel, while 19 Landscape Features are located inside of the Reference Parcel. Dataset VKP includes also other Landscape Feature types in comparison with other datasets such as SLF, LF-EFA, OLIL and ZABAGED. For example, LF type Grassland and LF Forest are present in the VKP dataset (see Table 17).

Table 17. Number of VKP Features according to spatial relationship with Reference Parcel

Landscape Feature Class and Type	Adjacent to RP	Borderline of RP	Inside of RP	In Total	In % of Total
Grassy Feature	**5**	**8**	**1**	**14**	**7.3 %**
louka, pastvina	4	5		9	64.3 %
other	1	1	1	3	21.4 %
occurrence		2		2	14.3 %
Stony Feature	**1**	**1**		**2**	**1.0 %**
lom, štola	1			1	50.0 %
strž, údolnice		1		1	50.0 %
Wet Feature	**15**	**24**	**1**	**40**	**20.8 %**
mokřad	2	1		3	7.5 %
nádrž, rybník, tůň	2	3	1	6	15.0 %
rybník	1			1	2.5 %
tok	1	2		3	7.5 %
vodní tok	9	18		27	67.5 %
Woody Feature	**35**	**84**	**17**	**136**	**70.8 %**
alej	9	37	1	47	34.6 %
les	6	15	2	23	16.9 %
mez, cesta, úvoz	3	19	4	26	19.1 %
remíz	2	4	4	10	7.4 %
stromy	15	9	6	30	22.1 %
In Total	**56**	**117**	**19**	**192**	**100.0 %**
In % of Total	**29.2 %**	**60.9 %**	**9.9 %**	**100.0 %**	**-**

Most of the Landscape Features existing in the dataset VKP are located on Grassland (see **Chyba! Nenalezen zdroj odkazů.**). Nevertheless, in comparison with other datasets, the VKP dataset has relatively small number of Landscape Features, in general. However, it should be borne in mind that the VKP dataset was available only for two pilot areas – Výprachtice and Odry (see Table 1), while other datasets (except LUCAS) were available for all test areas.

Table 18. Number of VKP Features according to the type of Agricultural land

Landscape Feature Class and Type	Adjacent to RP	Arable Land	Grassland	Permanent Cropland	In Total	In % of Total
Grassy Feature	**5**	**2**	**7**		**14**	**7.3 %**
louka, pastvina	4	1	4		9	64.3 %
other	1		2		3	21.4 %
occurrence		1	1		2	14.3 %
Stony Feature	**1**		**1**		**2**	**1.0 %**
lom, štola	1				1	50.0 %
strž, údolnice			1		1	50.0 %
Wet Feature	**15**	**3**	**21**	**1**	**40**	**20.8 %**
mokřad	2	1			3	7.5 %
nádrž, rybník, tůň	2	1	3		6	15.0 %
rybník	1				1	2.5 %
tok	1		2		3	7.5 %
vodní tok	9	1	16	1	27	67.5 %
Woody Feature	**35**	**30**	**70**	**1**	**136**	**70.8 %**
alej	9	20	17	1	47	34.6 %
les	6	1	16		23	16.9 %
mez, cesta, úvoz	3	3	20		26	19.1 %
remíz	2	3	5		10	7.4 %
stromy	15	3	12		30	22.1 %
In Total	**56**	**35**	**99**	**2**	**192**	**100.0 %**
In % of Total	**29.2 %**	**18.2 %**	**51.6 %**	**1.0 %**	**100.0 %**	**-**

In the pilot area Výprachtice, there are only two Landscape Feature types present in VKP dataset: Watercourse and Forest. In the Odry pilot area, there are also other types of LFs present in the dataset (see **Chyba! Nenalezen zdroj odkazů.**). It is thought that this uneven distribution of the number and types of Landscape Features is caused by lack of specific methodology for the data gathering and dataset creation.

Table 19. Number of VKP Features according to Test Areas

Landscape Feature Class and Type	599701 Odry	581178 Výprachtice	In Total	In % of Total
Grassy Feature	**14**		**14**	**7.3 %**
louka, pastvina	9		9	64.3 %
other	3		3	21.4 %
occurrence	2		2	14.3 %
Stony Feature	**2**		**2**	**1.0 %**
lom, štola	1		1	50.0 %
strž, údolnice	1		1	50.0 %
Wet Feature	**12**	**28**	**40**	**20.8 %**
mokřad	3		3	7.5 %
nádrž, rybník, tůň	6		6	15.0 %
rybník		1	1	2.5 %
tok	3		3	7.5 %
vodní tok		27	27	67.5 %
Woody Feature	**118**	**18**	**136**	**70.8 %**
alej	47		47	34.6 %
les	5	18	23	16.9 %
mez, cesta, úvoz	26		26	19.1 %
remíz	10		10	7.4 %
stromy	30		30	22.1 %
In Total	**146**	**46**	**192**	**100.0 %**
In % of Total	**76.0 %**	**24.0 %**	**100.0 %**	**-**

3.2.6 SWF

The Dataset SWF contains only Woody Features, as well as the OLIL dataset. However, the SWF dataset contains three times smaller amount of Landscape Features than OLIL dataset (see Table 11 and Table 20). Most of the Woody Features are located on the borderline of RP (see Table 20).

Table 20. Number of SWF according to spatial relationship with Reference Parcel

Landscape Feature Class and Type	Adjacent to RP	Borderline of RP	Inside of RP	In Total	In % of Total
Woody Feature	**661**	**2 772**	**544**	**3 977**	**100.0 %**
Additional Woody Features	56	356	45	457	11.5 %
Linear structures of trees, Hedges, bushes and scrub	529	2 148	287	2 964	74.5 %
Patchy structures of trees, Hedges, bushes and scrub	76	268	212	556	14.0 %
In Total	**661**	**2 772**	**544**	**3 977**	**100.0 %**
In % of Total	**16.6 %**	**69.7 %**	**13.7 %**	**100.0 %**	**-**

As in other datasets, Landscape Features are most frequently located on the Grassland, and the least frequently present on the Permanent Cropland (see Table 21).

Table 21. Number of SWF according to type of Agricultural land

Landscape Feature Class and Type	Adjacent to RP	Arable Land	Grassland	Permanent Cropland	In Total	In % of Total
Woody Feature	**669**	**899**	**2 363**	**46**	**3 977**	**100.0 %**
Additional Woody Features	59	91	301	6	457	11.5 %
Linear structures of trees, Hedges, bushes and scrub	534	708	1 686	36	2 964	74.5 %
Patchy structures of trees, Hedges, bushes and scrub	76	100	376	4	556	14.0 %
In Total	**669**	**899**	**2 363**	**46**	**3 977**	**100.0 %**
In % of Total	**16.8 %**	**22.6 %**	**59.4 %**	**1.2 %**	**100.0 %**	**-**

The distribution of Landscape Features among pilot regions is similar to other datasets. Landscape Features are mainly located in mountain regions, while the amount of LFs in regions with Arable land is small (see Table 22).

Table 22. Number of SWF according to Test Areas

Landscape Feature Class and Type	560294	564656	555941	592170	549517	549576	544566	599701	581178	In Total	In % of Total
	Březová	Budyně nad Ohří	Čachrov	Hluk	Kovářov	Milev-sko	Nový Hro-zenkov	Odry	Výpra-chtice		
Woody Feature	**364**	**351**	**560**	**230**	**867**	**493**	**448**	**425**	**239**	**3 977**	**100.0 %**
Additional Woody Features	40	30	104	25	86	47	52	47	26	457	11.5 %
Linear structures of trees, Hedges, bushes and scrub	257	286	361	188	656	375	324	333	184	2 964	74.5 %
Patchy structures of trees, Hedges, bushes and scrub	67	35	95	17	125	71	72	45	29	556	14.0 %
In Total	**364**	**351**	**560**	**230**	**867**	**493**	**448**	**425**	**239**	**3 977**	**100.0 %**
In % of Total	**9.2 %**	**8.8 %**	**14.1 %**	**5.8 %**	**21.8 %**	**12.4 %**	**11.3 %**	**10.7 %**	**6.0 %**	**100.0 %**	**-**

3.3 Comparative statistical analysis

The datasets were compared among each other, and spatial analysis was done according to the methodology described in Chapter 2.2 of this document.

The first comparison was focused on the occurrence of Landscape Feature types among the individual datasets. The second comparison was concentrated on determination of the relative representation of Landscape Features in individual Landscape Feature classes (see Table 23). The outcome shows that Woody Features are the most frequent LFs (> 48,8 %), while Grassy Features are the least frequent LFs (< 7,3 %) among all datasets.

The ZABAGED dataset represents a topographic database of all objects (including LFs), and the distribution of LFs is more regular than in other datasets, such as LF-EFA, OLIL, SLF (see Table 23).

Table 23. Number and relative frequency of Landscape Features among the datasets

Dataset		SLF	LF-EFA	OLIL	ZABAGED	VKP	SWF
Frequency of LF		**13 287**	**4 030**	**14 847**	**3 826**	**192**	**3 977**
Woody Features	Frequency	12 515	3 961	14 847	1 867	136	3 977
	[%]	94.4	98.3	100	48.8	70.8	100
Grassy Features	Frequency	11	14			14	
	[%]	0.1	0.3			7.3	
Wet Features	Frequency	244	31		1 206	40	
	[%]	1.8	0.8		31.5	20.8	
Stony Features	Frequency	486	24		753	2	
	[%]	3.7	0.6		19.7	1	

The results of comparison were divided to three categories according to the Table 4: Add Landscape Feature to LF-EFA dataset (“Add LF”), Keep Landscape Feature in LF-EFA dataset (“Keep LF”), and Verify the LF in the LF-EFA dataset (“Verify LF”). For the categories “Keep LF” and “Add LF” in the LF-EFA dataset, the further comparison was applied according to the value of attributes of LF class and LF type.

The results of the comparative analysis indicate that it would be useful to add 9 817 LFs from the SLF dataset into the LF-EFA dataset (see Table 24); which accounts for 74 % of the total number of LFs of the SLF dataset.

Contrary, it would be useful to verify 518 LFs registered in the LF-EFA dataset, since these are existing in this dataset, but at the same time are not present in the SLF dataset. It accounts for 12.85 % of the total number of registered LFs in LF-EFA dataset (Table 24).

In total, there are 3 714 LFs identified in the category “Keep LF” in the LF-EFA dataset. These LFs are present in both datasets – LF-EFA and SLF at the same time, and account for 92% of all features in the LF-EFA dataset, and 28% of all features in the SLF dataset (see Table 24).

Table 24. Frequency of detected possible activities in dataset LF-EFA

	Frequency	[%]
Add LF	9 817	74.07
Verify LF	518	12.85
Keep LF	3 714	92.06

3.3.1 Add LF

Landscape Features (9 817 LF) that were indicated as useful for adding to the LF-EFA dataset, were further compared with ZABAGED, OLIL, VKP and SWF datasets. In this step, the usability of third-party datasets for extending the LF-EFA dataset was examined in detail.

It should be noted, that the total number of Landscape Features after linking the third-party datasets (see Table 25) doesn't match the number of Landscape Features in Table 24; since the links between the LFs in individual datasets do not equal to 1:1 value (e.g. one LF in the SLF dataset could be represented by more LFs in third party datasets).

The OLIL dataset achieves the best results after linking the individual datasets with 68 % compliance rate. Contrary, the poorest results were achieved for the VKP dataset with only 1.67% compliance rate (see Table 25).

Table 25. Matching between Add to LF-EFA and third-party datasets

Add data	exist	don't exist	exist [%]	don't exist [%]	in total
ZABAGED	2 743	7 714	26.23	73.77	10 457
OLIL	7 139	4 930	68.27	47.15	12 069
VKP	175	9 651	1.67	92.29	9 826
SWF	2 462	7 821	23.54	74.79	10 283

Following the above comparison, the further analysis has been carried out. The absolute and relative frequencies of Landscape Feature classes in SLF dataset and third-party datasets were analysed (see Table 26). The outcomes show that for certain LF classes the third-party datasets contain more LFs than the SLF dataset (Table 26).

It should be also noted that Landscape Features in datasets of third parties have a different attribute values of LF classes than in SLF dataset.

Table 26. Frequency of matching between Add to LF-EFA and third-party datasets according to Landscape Feature Class

	Grassy Features	Stony Features	Wet Features	Woody Features
Add from SLF	**5**	**447**	**205**	**9 162**
ZABAGED	0	174	800	1 769
OLIL	0	0	0	7 139
VKP	9	1	19	146
SWF	0	0	0	2 462

ZABAGED [%]	0.00	38.93	390.24	19.31
OLIL [%]	0.00	0.00	0.00	77.92
VKP [%]	180.00	0.22	9.27	1.59
SWF [%]	0.00	0.00	0.00	26.87

Different Landscape Feature Class

During the comparison, the differences among the classified LF classes were also identified. For example, in dataset "Add LF" some LFs are classified as Woody Features, while the same LFs are classified as Stony Features in the ZABAGED dataset (see Table 27). Likewise, in dataset ZABAGED some of the Wet Features do not match with the "Add LF" class, since they are classified as Woody LFs in this set (see Table 27).

It is supposed, that one of the reasons for this discrepancy is the common presence of the vegetation around the Wet Features. Therefore, the visual interpreter of orthoimagery has determined that as Woody Feature in the SLF dataset, instead of Wet Feature as registered in ZABAGED dataset. The second reason could be represented by the fact, that ZABAGED dataset is generated not only on the basis of the visual interpretation, but also includes terrain visits, while SLF dataset is based purely on the visual interpretation of the orthoimagery.

Similar finding as above are relevant for the comparison between the "Add LF" class and VKP dataset (see Table 27).

Dataset OLIL and SWF contain only Woody Features. Hence, the discrepancies were found only between Woody Features and Other LF classes in comparison with "Add LF" class (see Table 27).

Table 27. Different Landscape Features Class in third party dataset and Add LF

Add LF	No match	Grassy Features	Stony Features	Wet Features	Woody Features	In Total
ZABAGED						
Grassy Feature	3			1	1	5
Stony Feature	415		25	5	4	449
Wet Feature	107			143	31	281
Woody Feature	7 189		149	651	1 733	9 722
In Total	7 714		174	800	1 769	10 457
OLIL						
Grassy Feature	3				7	10
Stony Feature	415				56	471
Wet Feature	120				139	259
Woody Feature	4 392				6 937	11 329
In Total	4 930				7 139	12 069
VKP						
Grassy Feature	5					5
Stony Feature	447					447
Wet Feature	202	2		1		205
Woody Feature	8 997	7	1	18	146	9 169
In Total	9 651	9	1	19	146	9 826
SWF						

Grassy Feature	3				3	6
Stony Feature	430				20	450
Wet Feature	160				54	214
Woody Feature	7 228				2 385	9 613
In Total	7 821				2 462	10 283

3.3.2 Verification LF

The category "Verification LF" is the result of comparison between SLF and LF-EFA datasets. This category represents Landscape Features that are present in LF-EFA dataset, but do not exist in SLF dataset. In this category, the visual verification against orthoimagery and ancillary LPIS data would be recommended, as necessary. It could happen that the LF could be located within the area of the Physical block, however is not located within the area of the Farmer´s block; counted as the Reference Parcel. In such situation, it is wanted that the Landscape Feature remains in the LF-EFA dataset, and not be deleted. Likewise, the LF should remain in LF-EFA dataset in case the operator missed that LFs during the mapping of LFs when creating the SLF dataset, as a mistake.

Following the analysis, 518 Landscape Features were identified to fit in the category "Verify LF". Most of them (98,46 %) are represented by Woody Features (see Table 28), of which Isolated trees count for 52.51 %, and Trees in group count for 38.80 %.

Table 28. Frequency of Landscape Feature class for "Verify LF"

Landscape Feature Class	Frequency	[%]
Grassy Feature	4	0.77
Stony Feature	1	0.19
Wet Feature	3	0.58
Woody Feature	510	**98.46**
In Total	518	100

The summary statistics of frequency of individual LFs types within the "Verify LF " category is reported in Table 29.

Table 29. Frequency of Landscape Feature type for "Verify LF"

Landscape Feature Class	Landscape Feature Type [CZ]	Landscape Feature Type [EN]	Frequency	[%]
Grassy Feature	Biopás	Bio-belt	3	0.58
	Travnatá údolnice	Grassed thalweg	1	0.19
Stony Feature	Terasa	Terrace	1	0.19
Wet Feature	Mokřad	Small wetland	3	0.58
Woody Feature	Mez	Hedge	28	5.41
	Skupina dřevin	Trees in group	201	**38.80**
	Solitérní dřevina	Isolated tree	272	**52.51**
	Stromořadí	Tree line and avenue	9	1.74
Total			518	100.00

3.3.3 Keep LF

In total, there are 3 710 LFs in LFA-EFA dataset that are present in both datasets (LF-EFA and SLF) at the same time. However, only some features match the same LF category. The most problematic Landscape Features are Stony and Wet Features that reach approximately 50 % compliance rate (see Table 30).

Table 30. Matching Landscape Feature Class between SLF and LF-EFA

SLF/LF-EFA Landscape Feature Class	no matching	matching	matching [%]	in total
Grassy Feature		6	100.00	6
Stony Feature	16	23	58.97	39
Wet Feature	28	25	47.17	53
Woody Feature	22	3 590	99.39	3 612
In total	66	3 644	98.22	3 710

In dataset LF-EFA some Landscape Features are registered as Woody Features, while in dataset SLF as Stony Features (see Table 31). This difference could be caused by the fact, that the visual photointerpretation is a regular part of the creation of SLF dataset. The similar situation is valid for the comparison between Wet and Woody Features (see Table 31).

Table 31. Changes between Landscape Feature Classes in SLF and LF-EFA

SLF/LF EFA no matching Landscape Feature Class	Grassy Feature	Wet Feature	Woody Feature	in total
Stony Feature		1	15	16
Wet Feature	2		26	28
Woody Feature	8	14		22
In total	10	15	41	66

Further on, more detailed classification of Landscape Feature mismatch types were elaborated. These discrepancies are more frequent for LF type (968 LF; see Table 32) than for LF class (see Table 31), since LF class could hold more LF types. Most of the differences are spotted within the LF class Woody Feature, especially between LF types Trees in group and Isolated tree (see Table 32 and chapter **Chyba! Nenalezen zdroj odkazů.**). Similar situation are among Hedge, Trees in group and Woody strips LF types. These Landscape Feature types are difficult to be distinguished based on the orthoimagery.

Other mismatches were identified between Natural stack of stone and Trees in group, and between Inland channels of fresh water and Isolated trees.

Table 32. Landscape Feature type mismatches between SLF and LF-EFA

LF Class	SLF/LF-EFA no matching LF type	Grassy Feature		Wet Feature	Woody Feature				In Total
		Bio-belt	Grassed thalweg	Small wetland	Hedge	Trees in group	Isolated tree	Tree line and avenue	
Stony Feature	Artificial stack of stone					1			1
	Natural stack of stone			1	2	**9**	2		14
	Terrace				1				1
Wet Feature	Ditch			2	4	2	1		9
	Inland channel of fresh water	1		1	1	2	**10**		15
	Man-made pond (Water body)		1						1
	Small wetland				1	3	2		6
Woody Feature	Hedge					**85**	**44**	5	134
	Isolated tree		1	6	**53**	**203**		6	269
	Riparian woody vegetation	1	2		1	3	1	1	9
	Tree line and avenue		1		25	6	11		43
	Trees in group	2	1	8	**84**		**288**	9	392
	Woody strip				**25**	**35**	7	7	74
In Total		4	6	18	197	349	366	28	968

3.4 Findings from the photointerpretation

3.4.1 Isolated tree on the borderline of Reference Parcel

Sometimes, it was quite challenging to make decision whether the Isolated tree on the borderline of the RP represents a LF or not.

Image 9. Isolated tree on the borderline of Reference Parcel

3.4.2 Isolated tree and Trees in group

The vectorisation of Small Landscape Features shown to be challenging process, especially regarding Woody Features. The recognition and decision whether the object is the Isolated tree or Trees in group holds an uncertainty. Mainly, due to the fact that trunks of two or three trees often grow together in cluster. Likewise, small shrubs are recognizable with difficulties only on the basis of the orthoimagery. In such situations, verification via terrain visits (or GT photo) could strongly support the final decision. However, that would be quite demanding process. On top of that, from the expert point of view, the decision whether the object is Isolated tree or Trees in group might not be a priority, as far as the object is correctly mapped as LF. Example of the situation is shown on the Image 10.

Image 10. Landscape Feature in the middle – is it one Isolated tree with two crowns grown together or two separated trees in a group?

3.4.3 Trees in group and Hedges (or Woody strips, Riparian woody vegetation and Tree lines and avenues)

For the purpose of this study, the rules for differentiation among the Trees in groups and Hedges (or Woody strips, Riparian woody vegetation, Tree lines and avenues) were defined by the team of operators prior to the vectorisation process. The Riparian woody vegetation is quite common Landscape Feature in the Czech Republic, however it is not defined in any national dataset as an individual category. Therefore, Riparian woody vegetation mapped by the operators during this study matches in large numbers only with some LFs from OLIL or ZABAGED datasets (Trees in group or Isolated trees).

It has been found out, that very often Landscape Feature fulfils definitions of the Hedge and the Riparian woody vegetation at the same time, and on top of that a Small watercourse is located at the same place too. Example of this situation is captured in the Image 11.

Image 11. Hedges, Riparian woody vegetation and Watercourse

3.4.4 Stony Features

Stony Features from ZABAGED dataset do not match with the situation shown in the orthoimagery map, and quite often vice versa. Lot of small natural Stacks of stones visible in the orthoimagery are not mapped in ZABAGED dataset, and contrary only part of mapped Stony Features (existing in ZADABED dataset) are really visible in the orthoimage. It has been identified, that mapped stones in ZABAGED dataset are parts of larger LFs, such as Hedges or Trees in group, quite often. The example of such situation is reported in the Image 12. The same situation is common for the Stack of stones (in ZABAGED database), that are usually located under the crowns of trees.

Image 12. Yellow colour shows Stony Feature from ZABAGED dataset which is a part of bigger Landscape Feature – Hedge (SLF)

4 CONCLUSION

Semantic and spatial analyses were performed as part of the IACS65 project to determine the usability of third-party databases for updating and extending the LF-EFA dataset, which is created within the LPIS database. The analyses included both datasets from the Czech data providers (VKP, OLIL, ZABAGED) and Pan-European datasets (LUCAS, SWF). Spatial analysis was performed on 9 test sites selected all over the Czech Republic. The LUCAS dataset was used only for the semantic analysis, because LUCAS data was not available at the time the spatial analysis was performed. The VKP dataset was available only for two test sites, specifically Výprachtice and Odry.

The semantic analysis shows that the datasets differ mainly in the method of data collection for the datasets creation, but also in the scale at which the datasets are produced. Some datasets are created by automated or semi-automated classification of aerial/satellite imagery (OLIL, SWF), while others are created based on visual interpretation of aerial/satellite imagery and field data collection (VKP, ZABAGED, LUCAS). In the Czech Republic, all third-party datasets have a scale of creation smaller than the LF-EFA dataset, which is created at the most detailed scale, namely 1 : 800. At the same time, datasets that are created by semi-automated classification from aerial/satellite imagery detect only Landscape Features from the LF class of Woody Features. This is due to the nature of these features, i.e. they are the easiest to detect on the aerial/satellite image. In contrast, the ZABAGED dataset generated by visual interpretation and field data collection, contains also Landscape Features from the LF class of Stony and Wet Features.

When comparing the classification of Landscape Feature types (LF type) of individual datasets, significant differences were found (refer to Table 5 in document Interim report_IACS_65_CZ_final). As the LF-EFA dataset is produced at the largest scale, the level of detail of the dataset classification is the most detailed one (13 LF types). The second most detailed dataset is the ZABAGED dataset (11 LF types), which also contains Landscape Features from non-LF class Woody Features. On the contrary, the least detailed classification is contained in the SWF dataset. There is only one LF type – Small Woody Features. The second least detailed dataset is the VKP dataset, which contains only 6 LF types.

Based on the analysis of the definitions of individual Landscape Features, it can be assumed that the third party datasets shall be primarily used as background data for the extension and update of the LF-EFA dataset (see chapter 2.4. in document Interim report_IACS_65_CZ_final), not as data that will replace the current method of creating the LF-EFA dataset (visual interpretation and field surveys). Some inconsistencies were identified regarding definitions, for example between Lone tree (ZABAGED) and Isolated tree (LF-EFA). Lone tree LF type (ZABAGED) contains only some significant trees, while all trees that meet the definition of Isolated tree (LF-EFA) shall be included in the dataset.

Likewise, linear vegetation in the ZABAGED dataset includes Riparian vegetation as well as Trees, but these are not distinguished by an attribute. The LF-EFA dataset does not include Riparian vegetation at all and Trees have a different definition, i.e. Trees along roads are not delineated. The LF-EFA dataset also contains almost no Stony Features, except for Terraces, unlike the ZABAGED dataset. At this point, based on semantic analysis, it is suggested that the ZABAGED dataset could be used to extend the LF-EFA dataset by Stony Features. Whether, this would be feasible shall be verified by spatial analysis.

As part of the spatial analysis, the SLF dataset was created by the CZ team. This dataset was taken as a reference, i.e. one that reflects the current situation of Landscape Features. For the dataset itself, the classification of Landscape Features that was defined in the framework of this project was used (refer to Table 1 in the Project brief). During the spatial analysis it was found out that some types of Landscape Features can be considered more as Landscape Features at the boundaries of the reference parcels (Hedge, Riparian woody vegetation, Group of trees, Woody strips), i.e. they are more linear type features. On the other hand, features that represent small areas (represented by a point in some databases) are more likely to be located within the reference parcel. It was also found out that in all datasets there are more Landscape Features present in permanent grassland than in other agricultural land use types. At the same time, it should be noted that test sites with higher elevation contain more Landscape Features than test sites located in lowland or mid-elevation areas.

The spatial comparison of the different datasets identified that in general third party datasets cover a small percentage of the Landscape Features that should be newly recorded in the LF-EFA dataset. The most useful third party dataset for extending the LF-EFA dataset appears to be the OLIL dataset. This dataset could thus be used to extend the LF class Woody Features. However, this also has its limitations. The first issue is the different classification of LF types within Woody Features, which are not in line. The second issue is the "jaggedness" of the boundaries of these objects in the OLIL dataset, which is due to the way the dataset is created. There is a similar problem with the SWF dataset, which in addition had to be transformed into the national coordinate system and the available software did not allow a more accurate

transformation than with an error of 1 m, which in some places, especially in mountain areas, caused a shift of Landscape Features from the reality. From the results of the spatial analysis, the ZABAGED dataset could be used to some extent for the LF-EFA extension with LF class Stony Features. However, even this extension has its limitations. In some cases, there are overlaps, e.g. Solitary Woody Vegetation with Solitary stone or Stack of stones, that are located under the tree crown. Contrary, in the ZABAGED dataset some Stony Features, despite being visible on the aerial/satellite image, are not included in the database.

During the actual vectorization of the SLF dataset, it was found out that it was quite difficult to distinguish some LF types from each other (Group of trees, Isolated tree or even Hedge, Riparian, Woody strip and Group of trees). For this reason, the expert team agreed that it would be more appropriate to simplify the LF-EFA classification to only four main groups of Landscape Features (Woody, Grassy, Wet and Stony Features), which would reduce the number of possible mistakes made by the operators determining the specific LF type.

Furthermore, it was also identified during the vectorisation that third party datasets shall be primarily used as background data for the production of LF-EFA. The main reasons are the spatial and content resolutions of the individual datasets, which are insufficient for the LF-EFA. In particular, ZABAGED for Woody and Stony Features and OLIL for Woody Features are suitable as background datasets.

Thus, to conclude, the analysis itself was very useful basis for further works regarding Landscape Features agendas and LF-EFA database update. Likewise, as a source of opening the issue of clarifications of definitions, simplification of LF classification, and harmonisation of LF agendas among stakeholders involved in this domain.

5 SOURCES

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