Ponderful
PONDS FOR CLIMATE

Deliverable D3.2

Report on Spatial Distribution

of Pondscapes in Europe

Pond Ecosystems for Resilient Future Landscapes in a Changing Climate

European Commission

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1. Executive Summary

The geo-referenced data on ponds in Europe (collected under Task 2.1, stratified sampling, in WP2 and Task 4.2, demo-sites, in WP4), existing spatial datasets on small water bodies in Europe, and newly available remote sensing products (Sentinel 1 and 2 from Copernicus and Landsat TM data) are combined to map the spatial distribution of pondscapes, assessing the density and distribution of ponds in different regions across Europe, with a focus on the regions where the stratified sampling will be done in the context of PONDERFUL project, spanning a wide climatic gradient in Europe. The spatial distribution of demo-sites from Uruguay is also included in this report. The spatial distribution of demo-sites, ponds already selected for stratified sampling and ponds from local databases in Europe is presented. This report presents the availability of the global and local databases of pondscapes and land use in Europe

2. Introduction

This report aims to present the spatial distribution of pondscapes in Europe. The pondscape data are obtained from global, local databases and satellite images. The attributes of the ponds are retrieved from the available databases and a common database is created. Besides the location of the existing ponds, the land use and land cover information are also retrieved from the available databases.

3. Pondscape Databases

The spatial distribution of pondscapes in Europe can be obtained from global and local databases. Existing global and local databases were retrieved. The global databases are open source and these databases are easy to obtain via search engines. However, most of the databases are too coarse and it may be hard to retrieve necessary information about the pondscapes. Local databases cover detailed information about the ponds. In the following section, the global and local databases for pondscapes are introduced and their features are presented.

3.1 Global Databases

Inherently, it is hard to compile a 'comprehensive' water body database including the ponds due to very small areas of ponds and this is one of the main reasons that the global databases have lots of limitations. For the PONDERFUL project, some utilizable global databases, especially for Europe, were gathered. Their features, limitations and providers are mentioned in this chapter.

3.1.1 Global Lakes and Wetlands Database

The World Wildlife Fund and the Center for Environmental Systems Research from University of Kassel created the 'Global Lakes and Wetlands Database[1]' (Figure 1). Available sources for

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[1] https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database

water bodies on a global scale are combined with the applications of Geographic Information System (GIS) Functionality and three levels of data are gathered. The levels are described as follows:

- Level 1: In this level of data, 3067 large lakes and 654 large reservoirs exist. The thresholds for lake areas and reservoir values are; Lake_Area $\geq$ 50 km^2 and Reservoir_Volume $\geq$ 0.5 km^3, respectively.

- Level 2: In this level of data, approximately 250,000 polygons with a surface area $\geq$ 0.1 km^2 exist.

- Level 3: In this level of data, there are no additional polygons. However, some additional information like maximum extents and types of wetlands of level 1 and level 2 polygons exist.
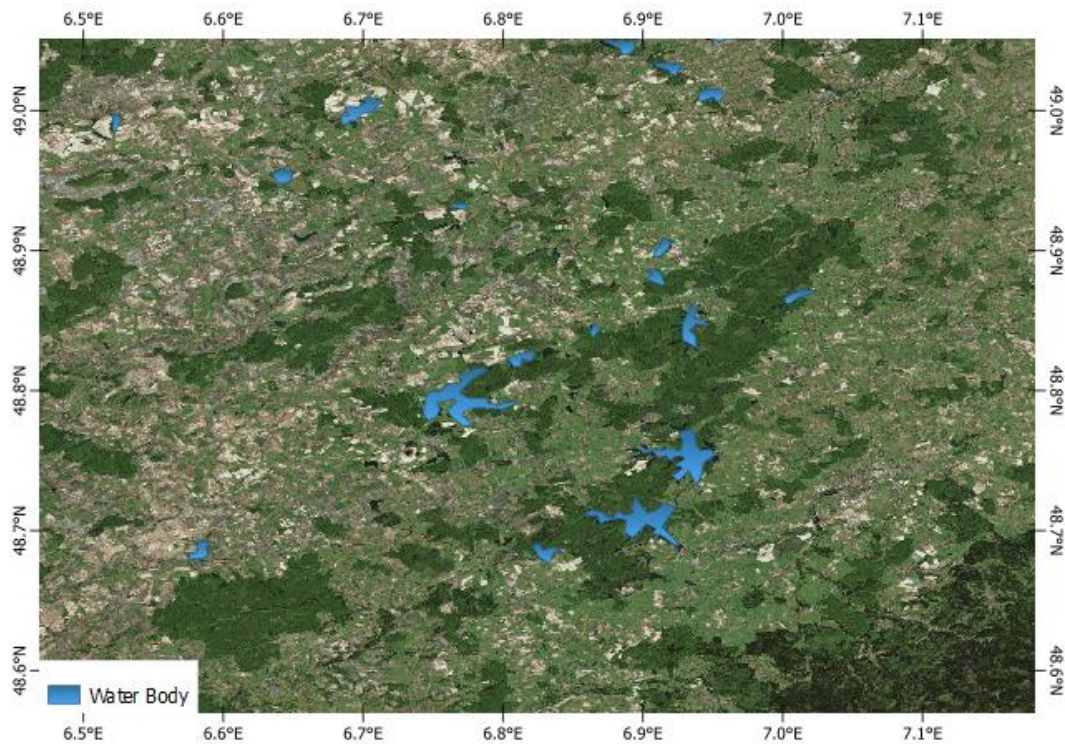

Figure 1. A snapshot from the WWF database

In this database, it is possible to obtain the surface areas, perimeters and locations (latitude/longitude) from the attributes (Table 1).

Table 1. Attributes of the database of WWF

GLWD_ID	TYPE	POLY_SRC	AREA_SKM	PERIM_KM	LONG_DEG	LAT_DEG
3722	Lake	DCW	49.9	67.4	90.96	68.93

3.1.2 Water Information System for Europe

The Water Information System for Europe (WISE)[2] database, which is managed by the European Environment Agency, is compiled from the River Basin Management Plans submitted by EU member states, Norway and the UK under the Water Framework Directive (WFD) to the European Commission. Five separate shape file archives can be obtained as '*River Basin Districts*', '*River Basin District Subunits*', '*Surface Water Bodies*', '*Groundwater Bodies*' and '*Monitoring Sites*'. The properties of the available data set are given in Table 2.

Table 2. WFD reference spatial data sets and corresponding shape files (Nery F., 2020)

Data set	Shapefile	Geometry type	Observations
River basin districts	RiverBasinDistrict	Polygon	
River basin district subunits	SubUnit	Polygon	
Surface water bodies	SurfaceWaterBody	Polygon	
	SurfaceWaterBodyLine	Polyline	
	SurfaceWaterBodyPoint	Point	Only for the 1st RBMP (WFD2010). The *shapefile* may contain empty geometries.
Groundwater bodies	GroundWaterBody	Polygon	
	GroundWaterBodyPoint	Point	Only for the 1st RBMP (WFD2010). The *shapefile* may contain empty geometries.
Monitoring sites	MonitoringSite	Point	The 1st RBMP (WFD2010) dataset may contain empty geometries.

In the database, there are roughly 40,000 water bodies from Europe with no threshold for the surface areas of the water bodies. So, some ponds having surface area smaller than 5 ha can be obtained from this database. However, only 3.75% of water bodies available in this database are smaller than 5 hectares. A general overview of the database can be seen in Figure 2.
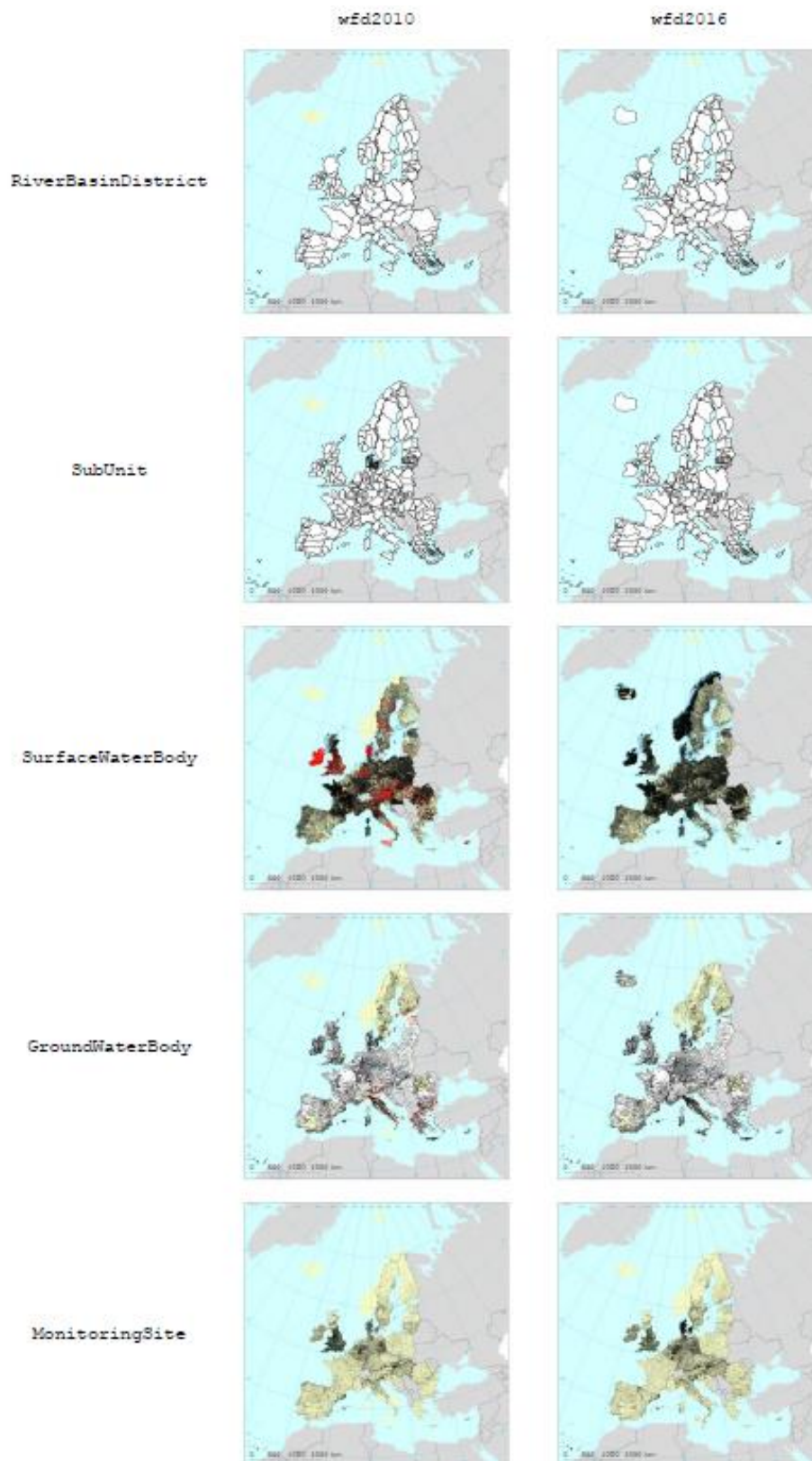
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[2] https://www.eea.europa.eu/data-and-maps/data/wise-wfd

Figure 2. Overview of the available data from WISE (Nery F., 2020)

3.1.3 Global Surface Water

Global Surface Water Database[3] is also another available database to utilize. Development and the compilation are progressed by The European Commission's Joint Research Centre for the Copernicus Programme. This dataset provides statistics, locations and temporal distribution of water surfaces at the global scale over the past 3.7 decades. The data is produced from three million Landsat images at 30-metre resolution (Pekel et al., 2016).

In the dataset, the following features can be obtained for water bodies between 1984 and 2020:

- Water Occurrence
- Water Occurrence Change Intensity
- Water Seasonality
- Annual Water Recurrence
- Water Transitions
- Maximum Water Extent

Although it is a big database to get different features of water bodies around the world, the surface areas of water bodies are still large to be used in PONDERFUL project and the data are in raster format.

3.1.4 Global Water & Wetness Database

The Copernicus Land Monitoring Service (CLMS) provides geographical information on land cover and its changes, water cycle etc. By the help of the incorporation of the High-Resolution Layers, four thematic High-Resolution Layers (HRL) on land cover characteristics for all of Europe at 10m spatial resolution, covering 39 countries with more than 6 million km² were created. It is possible to access the database[4] for free and the data is divided for each country in Europe. Some brief information about the database is given in Table 3 and overview of water and wetness database is presented in Figure 3.

Table 3. Information about Water & Wetness database.

HRL WAW 2018	Water and Wetness layer	Primary product
File name WAW_2018_010m_eu_03035_v2_0		
Reference year 2018 (based on 2012-2018 imagery)		
Geometric resolution Pixel resolution 10m x 10m, fully conform with the EEA reference grid		
Coordinate Reference System European ETRS89 LAEA projection / national projections		
Geometric accuracy (positioning scale) Less than half a pixel. According to ortho-rectified satellite image base provided through CSCDA		

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[3] https://global-surface-water.appspot.com/download

[4] https://land.copernicus.eu/pan-european/high-resolution-layers/water-wetness/status-maps/water-wetness-2018?tab=download
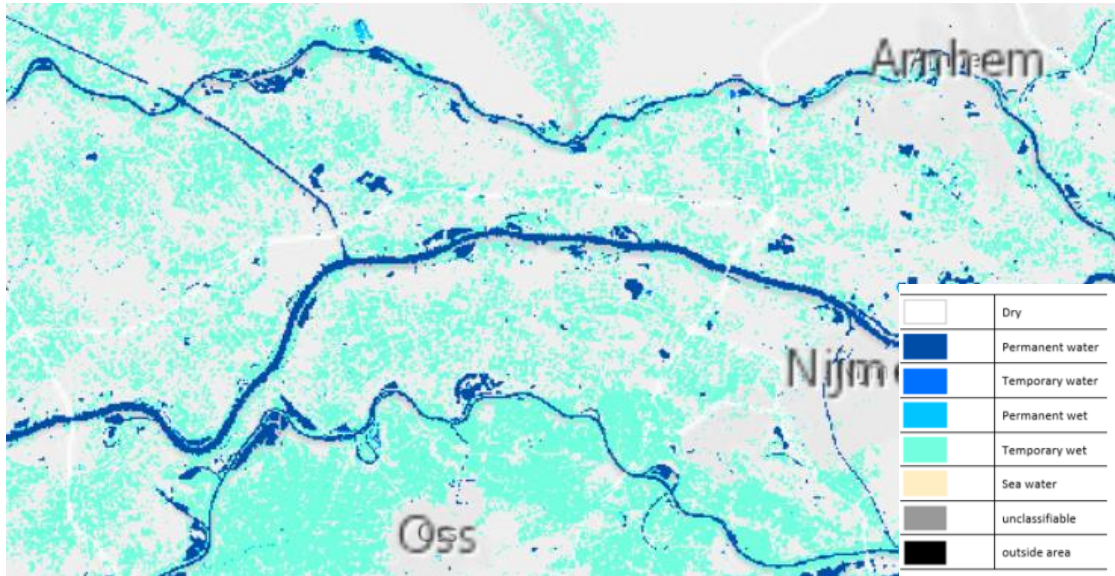
Figure 3. An overview of the Water & Wetness Database

3.1.5 Global Land Use Database: MODIS

MODIS (Moderate Resolution Imaging Spectroradiometer)[5] has a viewing swath width of 2,330 km and views the entire surface of the Earth every one to two days. 36 spectral bands between 0.405 μm and 14.385 μm are obtained and the data at three spatial resolutions (250m, 500m and 1000m) are compiled (Figure 4).

There are comprehensive products that researchers from a variety of disciplines use. Some of the products may be listed as follows:

- Atmosphere Products → Aerosol, cloud, precipitable water etc.
- Land Products → Land cover, evapotranspiration, surface temperature etc.
- Cryosphere Products → Snow cover, sea ice and ice surface temperature etc.
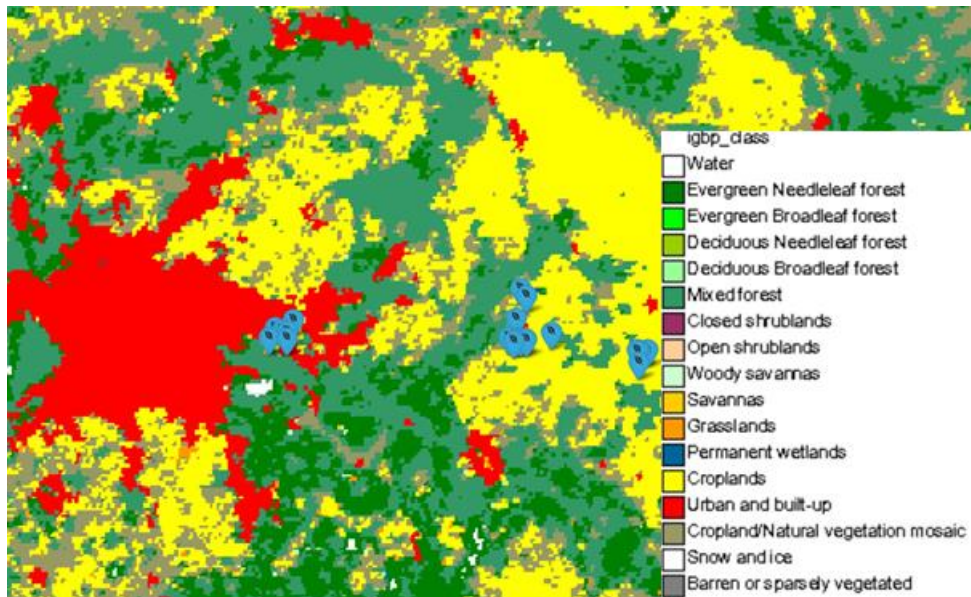- Ocean Products → Sea surface temperature, particulate organic carbon etc.

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[5] https://modis.gsfc.nasa.gov/data/

Figure 4. An example from MODIS land use information.

3.1.6 Global Land use Database: CORINE

The CORINE Land cover[6] was initiated in 1985 and consists of 44 land cover classes (Figure 5). The minimum mapping unit and minimum width are 25 ha and 100 m respectively. It is also free for all users. Some general information for the latest version (2018) can be mentioned as follows:

- Satellite Data → Sentinel-2 and Landsat 8-for gap filling.
- Time Consistency → 2017-2018
- Geometric Accuracy → ≤ 10 m
- Min. Mapping unit/width → 25 ha/ 100m
- Production Time → 1.5 years
- Thematic Accuracy → 85%
- Geometric Accuracy → better than 100 m
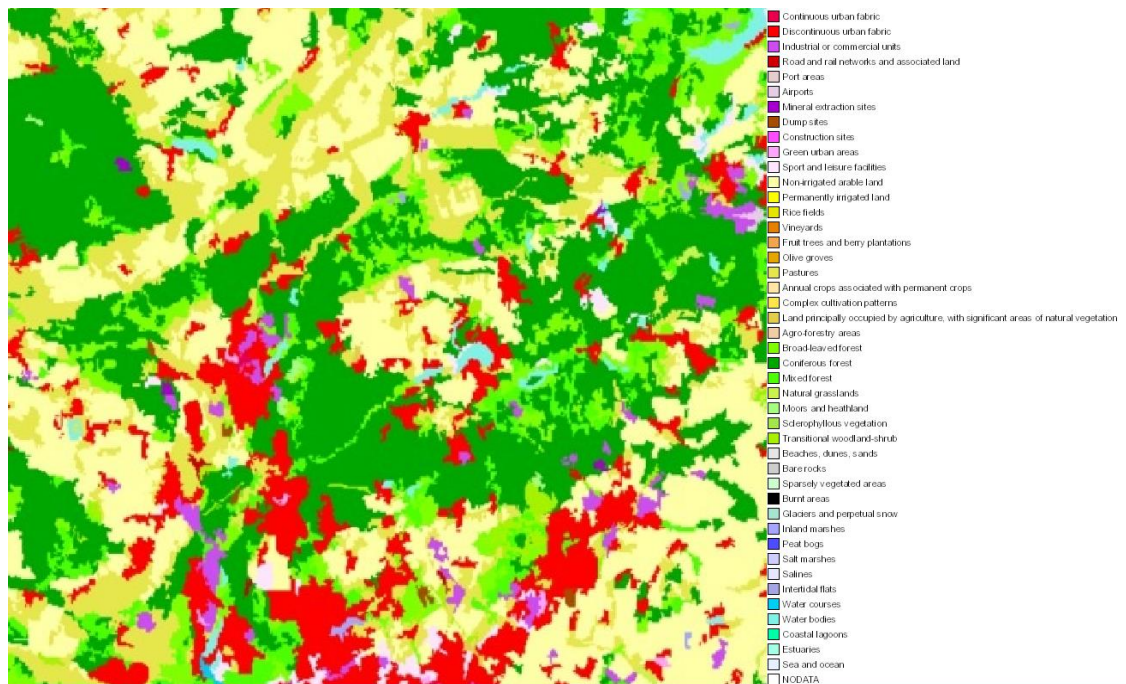- Number of Countries Involved → 39

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[6] https://land.copernicus.eu/pan-european/corine-land-cover

Figure 5. An example from CORINE land use information.

3.2 Local Databases

In this section, some shared databases are mentioned for European countries. As mentioned earlier, the global databases are too coarse to contain small water bodies, like ponds. Therefore, the local databases (from the countries participating in PONDERFUL for stratified survey and DEMO-sites) are crucial to present the spatial distribution of the pondscapes in Europe. Local databases and the relevant information about them are as follows:

3.2.1 Database of Denmark

There is a detailed database which can be obtained from 'The Danish Agency for Data Supply and Efficiency' as open access. The database[7] comprises many shape files for different purposes like catchments, ponds, rivers as hydrology or traffic lights, roads, bridges for traffic management etc. in Danish. Detailed subtitles for the database are as follows:

- Buildings
- Miscellaneous
- Hydrology
- Nature
- Technical
- Topography
- Traffic

The database can be used to retrieve small water bodies. There is no lower limit for areas and more than 250,000 water bodies exist in the database. Ponds retrieved from the databases perfectly match with the ones selected for PONDERFUL project (Figure 6).

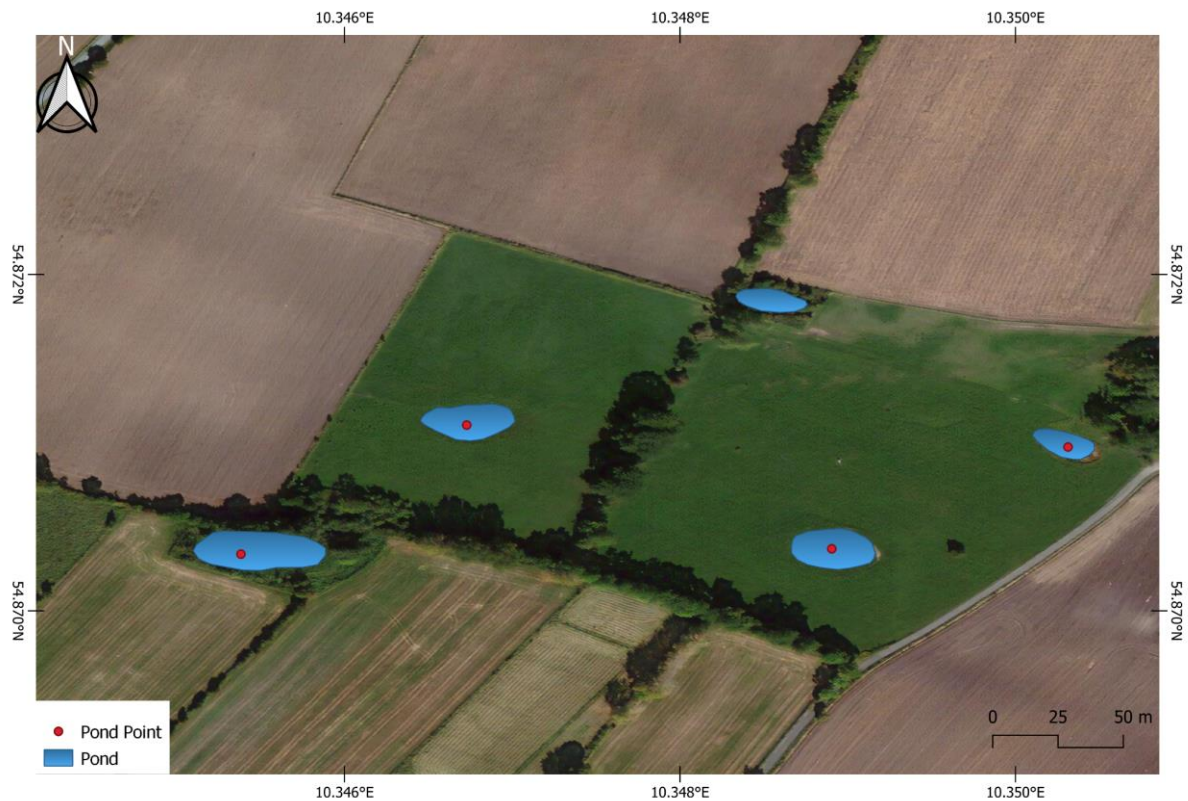[7] https://download.kortforsyningen.dk/content/geodanmark

Figure 6. A snapshot from the database of Denmark, red dots are the location of ponds selected for PONDERFUL

The attributes of polygons and the points of ponds have few information. Physical quantities like depth, altitude etc. are not available. Some information can be listed as follows:

- Feature type (all of them 'lake')
- Feature status (whether available or not)
- Time of creation

Besides the ponds, detailed designed land use maps are available. It is a raster data with relevant band numbers, an example of the map can be seen in Figure 7.
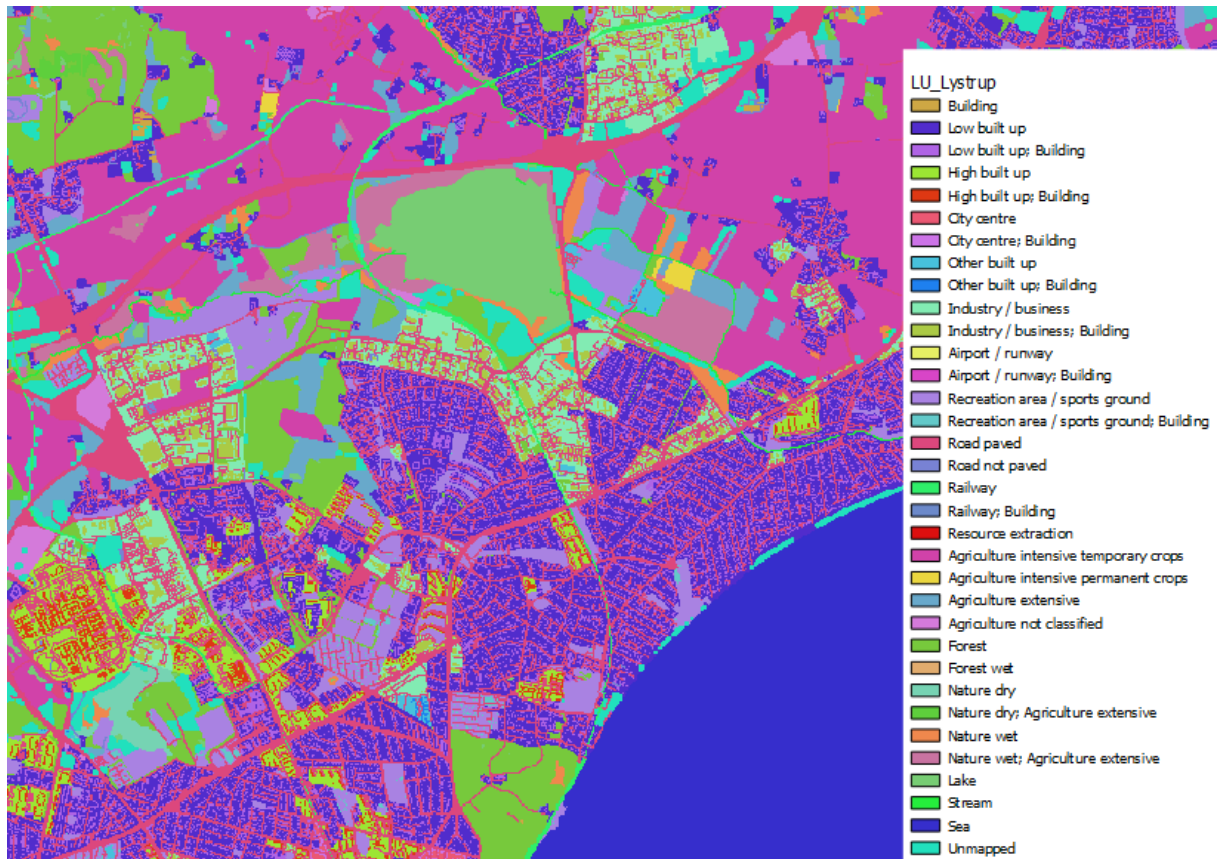
Figure 7. Land use map from the database of Denmark

3.2.2 Database of Belgium

Like Denmark, a detailed database also exists for Belgium. Likewise, no lower limit is obtained for areas of water bodies. The database comes from '*Geopunt Vlaanderen*'[8] . The database integrates 88.713 polygons having surface area with a range of 1.5 m² to 2.46 km². An example of overview with a demo pond, which depicts the local database from Geopunt matches with the ponds selected for PONDERFUL project, is presented in Figure 8. Red dot is the location of a pond from the PONDERFUL database.

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[8] https://www.geopunt.be/catalogus/datasetfolder/61c4245b-a177-4fe8-a5cc-455475d7b40f
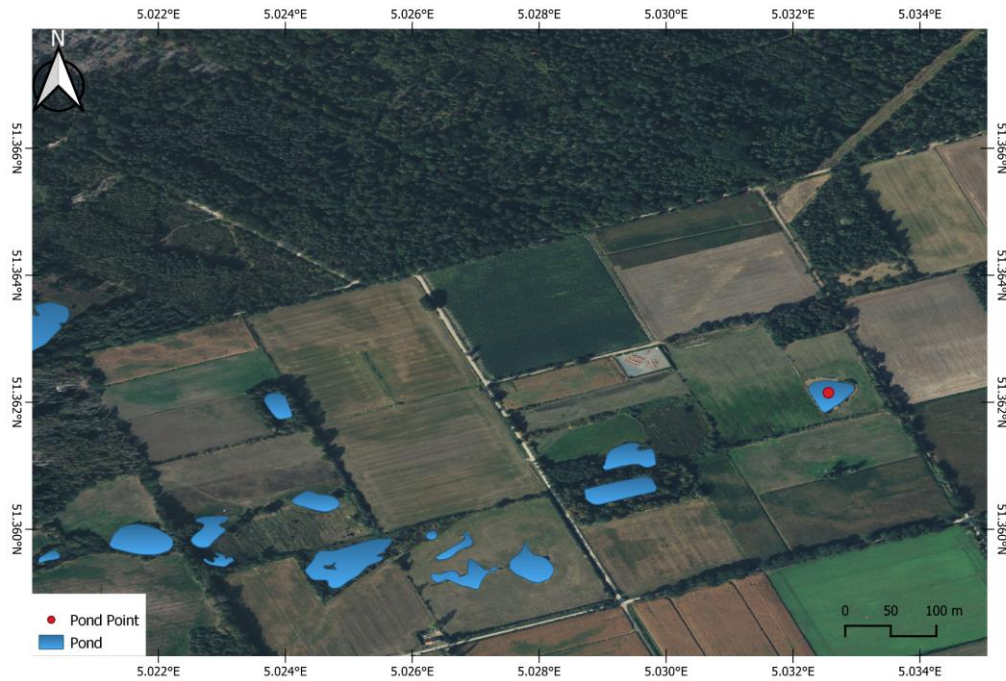
Figure 8. A snapshot from the database of Belgium with a demo pond point (red one).

The database comprises few attributes. No physical or environmental quantities are observed, but there is the location information in terms of latitude and longitude. Some attributes can be listed as follows:

- Name of the location
- Functions for few of them (reservoir etc.)
- Range of the depth for some of them (between 0-2 meters etc.)
- Surface area and perimeters
- Seasonality (permanent or not)

3.2.3 Database of Switzerland

A detailed land use and water body database exists for Switzerland[9]. More than 40,000 water bodies including the small ponds can be retrieved. Some physical quantities like area, perimeter etc. also exist in the land use database. Demo ponds are obtained from the land cover layer called as '*Eaux calmes végétalisées*' and from field knowledge which is needed for especially small temporary ponds.

Example overview for ponds and land use can be seen in Figure 9 and Figure 10, respectively.

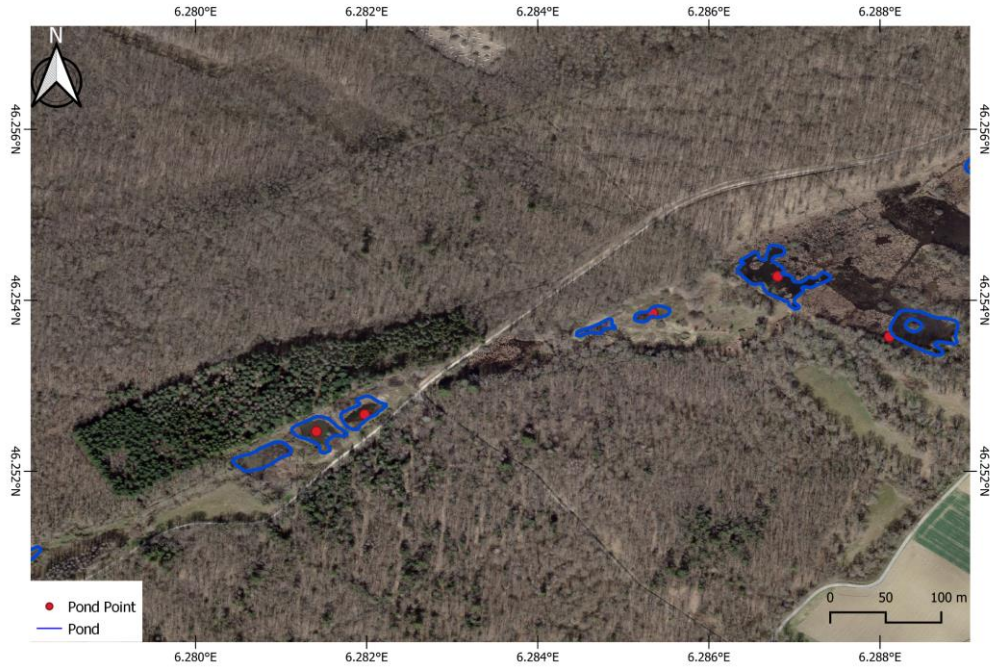[9]https://www.swisstopo.admin.ch/en/geodata/landscape/tlm3d.html

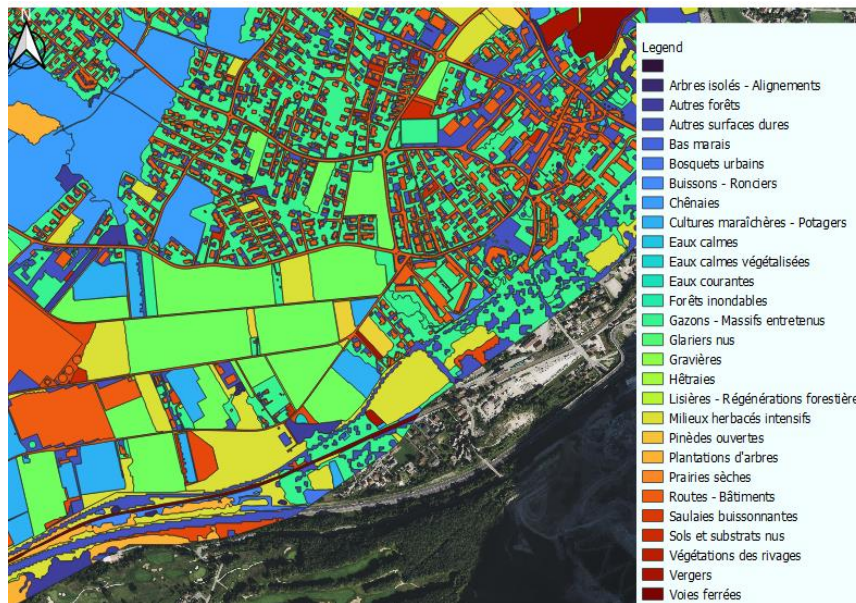Figure 9. A snapshot from the database of Switzerland.

Figure 10. An example from the database of Switzerland for land use.

3.2.4 Database of Turkey

A water body database exists for Turkey. The database includes small water bodies with a lower bound of 15 m^2. Example overview for ponds can be seen in Figure 11. The database is not public, it is obtained from Ministry of Agriculture and Forestry. Available land use database is obtained from CORINE database.
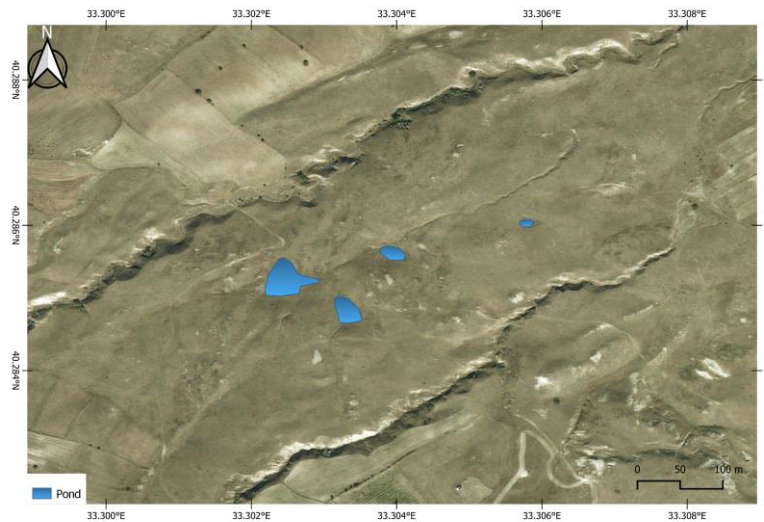
Figure 11. A snapshot from the database of Turkey.

3.2.5 Database of United Kingdom

A free access database is not available for United Kingdom. On the other hand, a website application[10] is available for assessment of ponds in England. A snapshot can be seen in Figure 12.
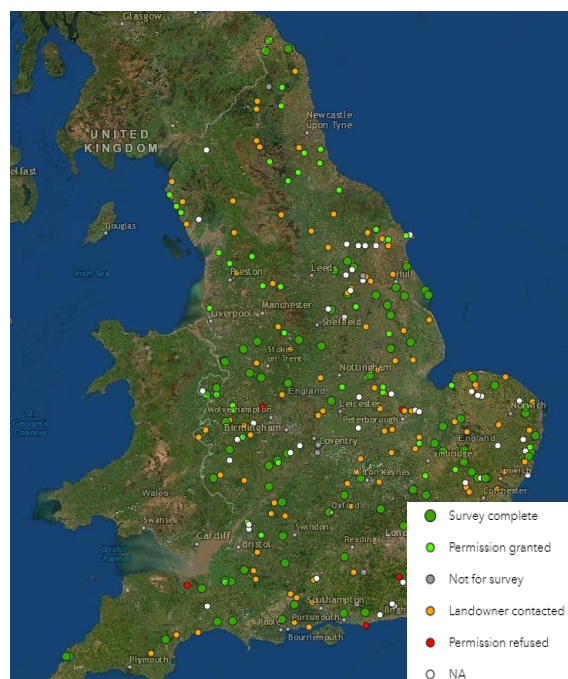

Figure 12. A snapshot from the ongoing database of the United Kingdom.

The attributes of local databases available for the PONDERFUL project (all the shared ponds for PONDERFUL from the project partners) are summarized in Table 4.

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[10] https://fht.maps.arcgis.com/apps/webappviewer/index.html?id=27395baedcb14951a9887cea8b879989

Table 4. Summary of common attributes for the local databases.

Country	Number of Ponds	Minimum Area(m²)	Available Depth Information	Available Function of Water Body	Land Use Information	Perimeter Information
Denmark	234,659	-	-	-	All	-
Belgium	88,713	1.45	Few	Some	All	All
Switzerland	41,592	4.8	-	-	All	All
Turkey	21,308	15	-	Some	All	All

3.3 PONDERFUL Pondscape Database

Spatial data of the ponds, which will be used for WP2, WP3 and WP4 are obtained from all the countries contributing to PONDERFUL, except Uruguay. So, these compilations were created with data to date. The distribution is presented in Figure 13. As new data are shared, they will be included in the database.
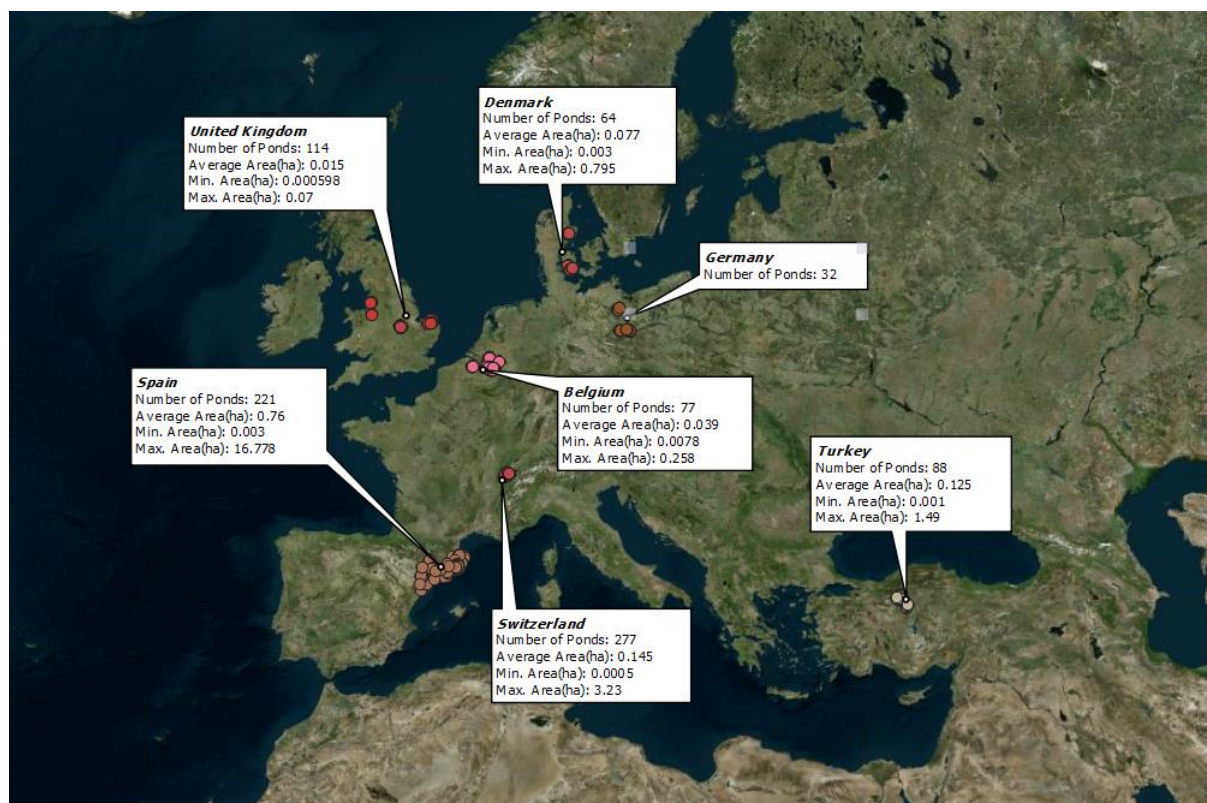

Figure 13. Spatial distribution of the ponds selected for PONDERFUL

3.3.1 Ponds in Belgium

77 ponds having surface area of 0.0078 ha and 0.258 ha are used in the project in WP2 and WP4. The distribution of the ponds is given in Figure 14. The number of the ponds those will be used for stratified sampling and as demo-ponds are given in Table 5.
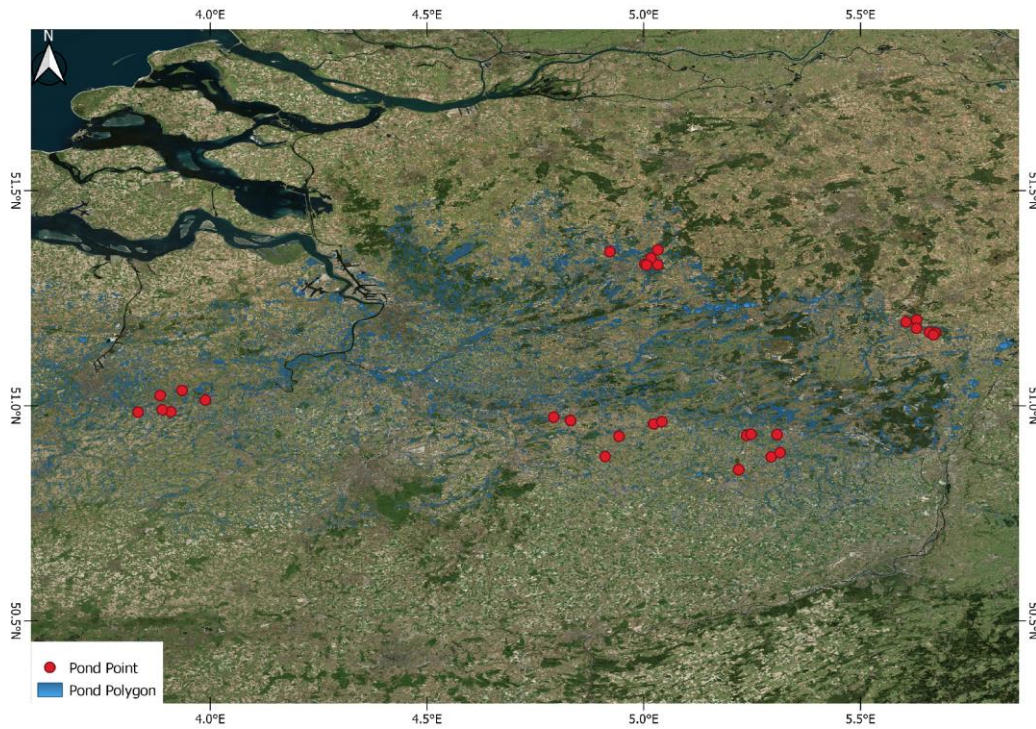
Figure 14. Spatial distribution of the ponds in Belgium

3.3.2 Ponds in Denmark

64 ponds having surface area of 0.003 ha and 0.795 ha are used in the project for WP2 and WP4. The distribution of the ponds is given in Figure 15. The number of the ponds those will be used for stratified sampling and as demo-ponds are given in Table 5.
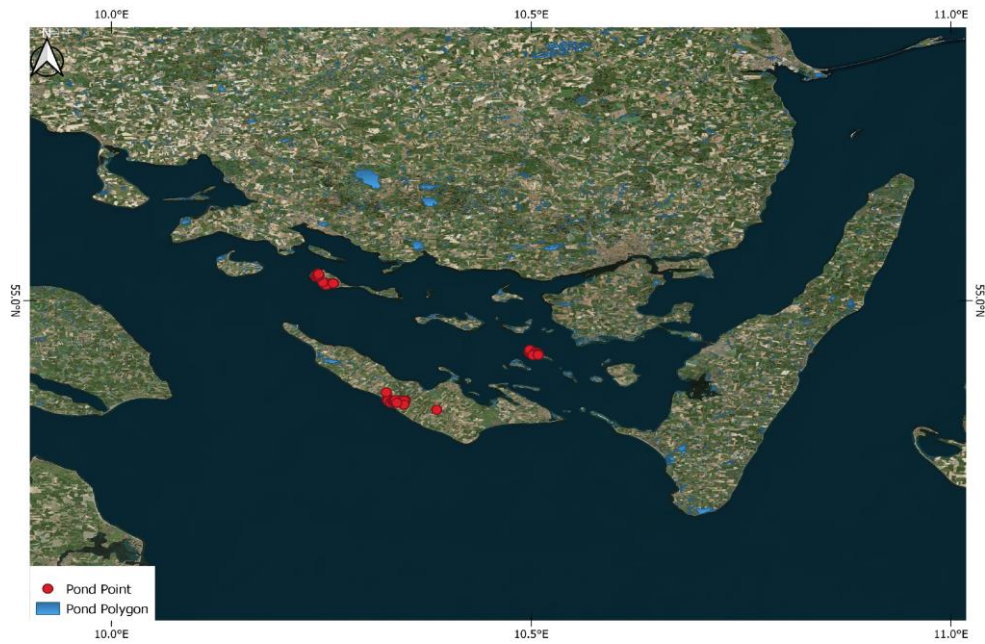
Figure 15. Spatial distribution of the ponds in Denmark.

3.3.3 Ponds in Germany

Only point data exists for the ponds from Germany. 32 Points of ponds are available. Spatial distribution of the ponds in Germany is given in Figure 16. The number of the ponds those will be used for stratified sampling and as demo-ponds are given in Table 5.
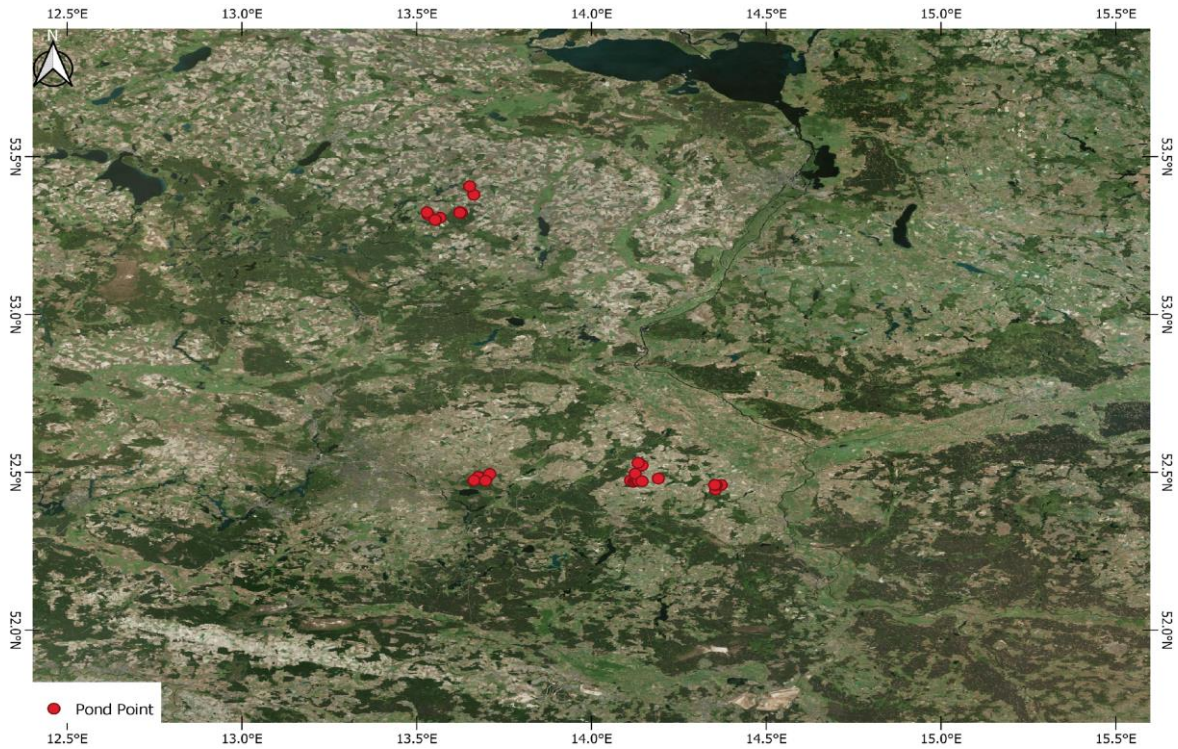
Figure 16. Spatial distribution of the ponds in Germany.

3.3.4 Ponds in Spain

Database for PONDERFUL project ponds is available for Spain. The database includes 221 ponds those are used in the project for WP2 (stratified survey) and WP4 (DEMO-sites) with detailed attributes (note: since at the time of writing this report the selection of the ponds for stratified survey is not completed, depending on water availability there may be slight changes in the final pond database). Spatial distribution of the ponds in Spain is given in Figure 17. The number of the ponds those will be used for stratified sampling and as demo-ponds are given in Table 5.
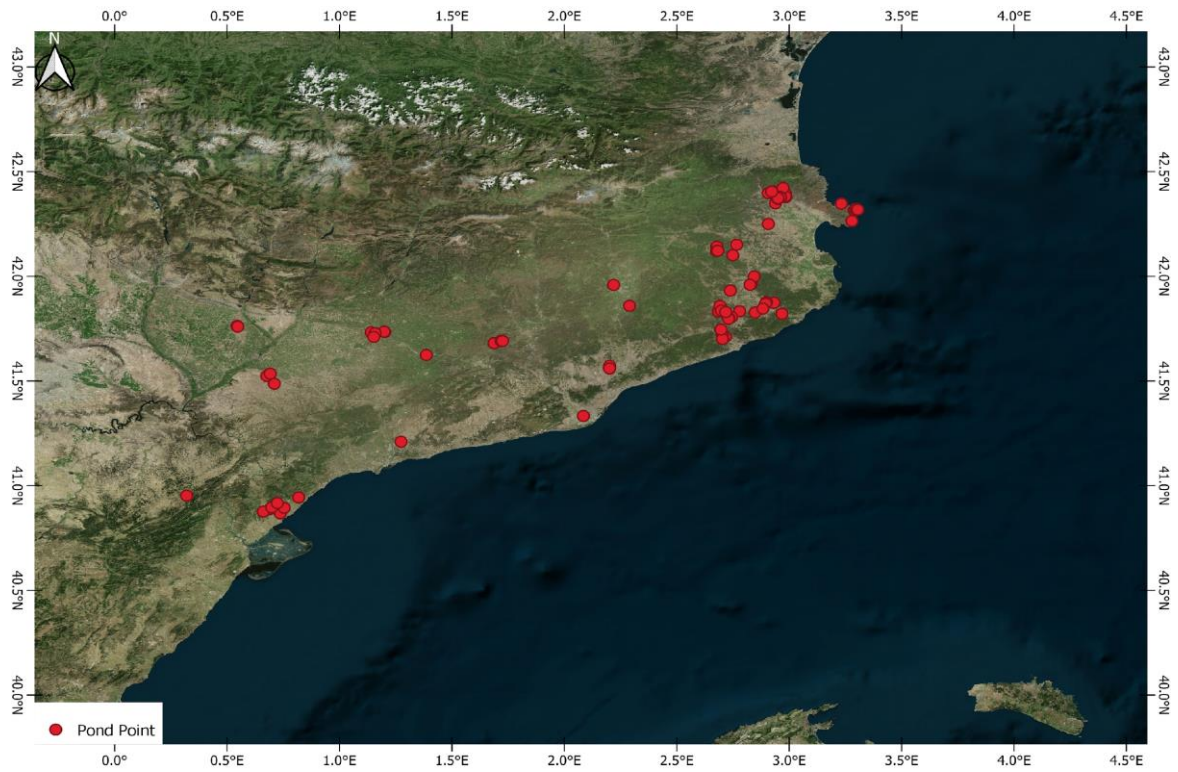
Figure 17. Spatial distribution of the ponds in Spain.

Some of the important attributes in the database are:
- Average, maximum and minimum temperature recorded.
- Area
- Altitude
- Type of the pond (i.e. artificial/natural)

3.3.5 Ponds in Switzerland

Polygons and points with the relevant attributes are ready for 261 ponds in Switzerland. Spatial distribution of the ponds in Switzerland is given in Figure 18. The number of the ponds those will be used for stratified sampling and as demo-ponds are given in Table 5.
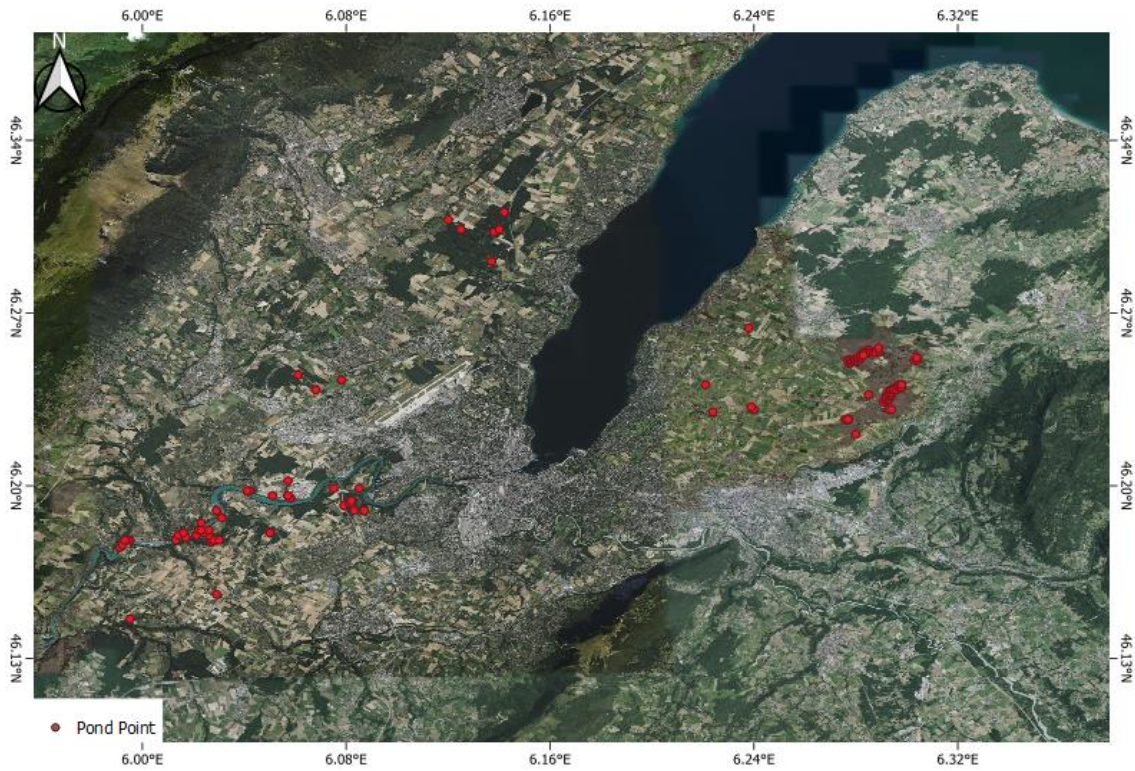
Figure 18. Spatial distribution of the ponds in Switzerland.

The Swiss database contains some important attributes, including   :
- Maximum depth
- Average Depth
- Altitude
- Area

3.3.6 Ponds in Turkey

Database of the ponds for PONDERFUL project is also available for Turkey. Shape of 88 ponds were prepared to utilize with area information. Spatial distribution of the ponds in Turkey is given in Figure 19.
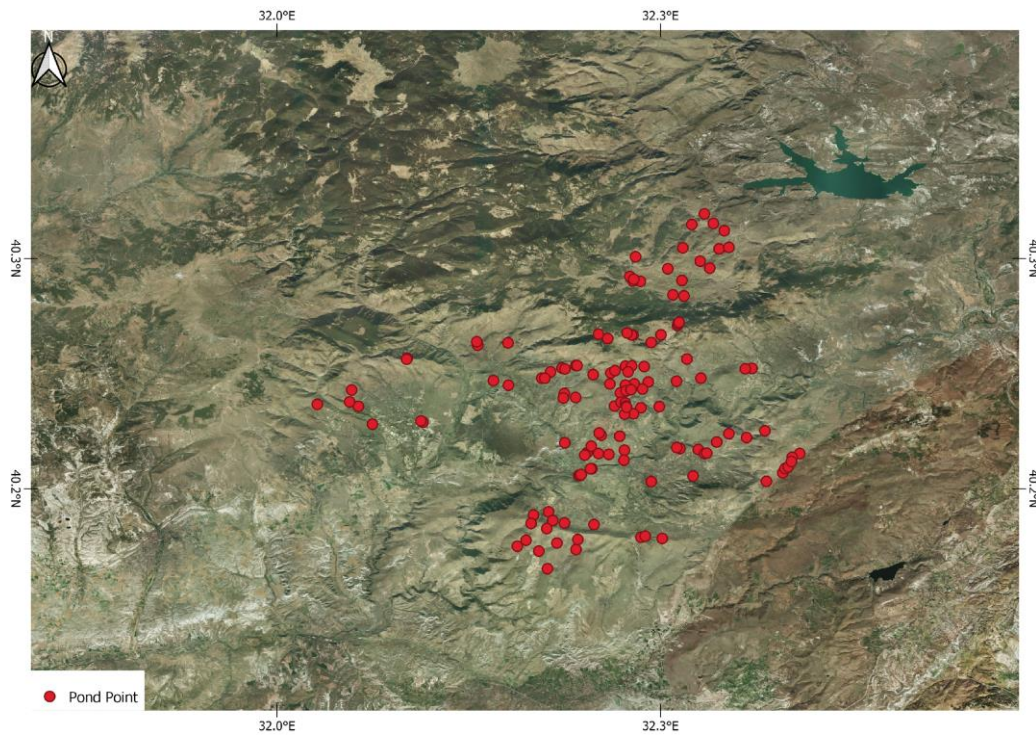
Figure 19. Spatial distribution of the ponds in Turkey.

3.3.7 Ponds in the United Kingdom

Polygons and points of the ponds are available for the United Kingdom including the shape lengths and areas. Spatial distribution of the ponds in the United Kingdom is given in Figure 20.
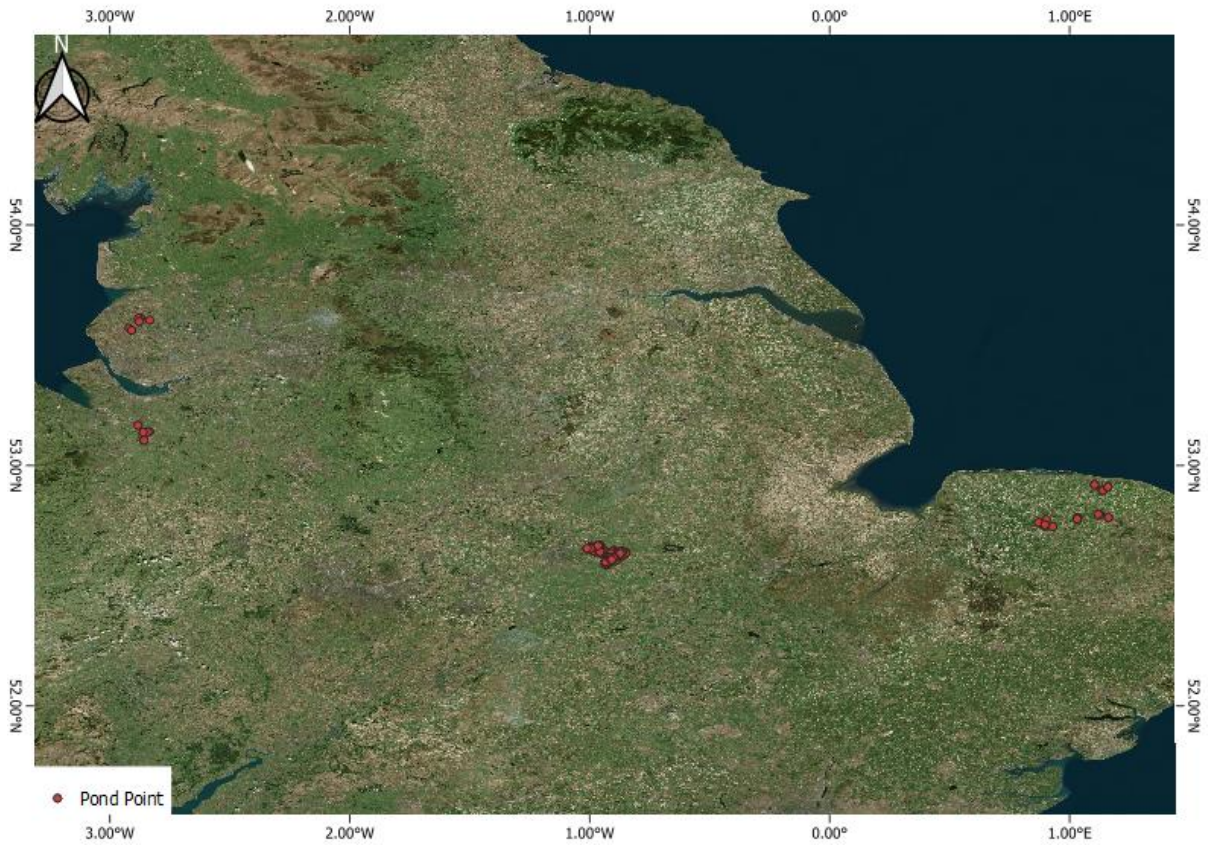
Figure 20. Spatial distribution of the ponds in the United Kingdom.

Additionally, there are some pondscapes/meadows from the UK with detailed descriptions (Figure 21).

Figure 21. A meadow from the shared UK database.

3.3.8 Ponds in Uruguay

There are 19 DEMO pond locations for ponds in Uruguay. Only the location information exists. Spatial distribution of the ponds in the Uruguay can be seen in figure 22
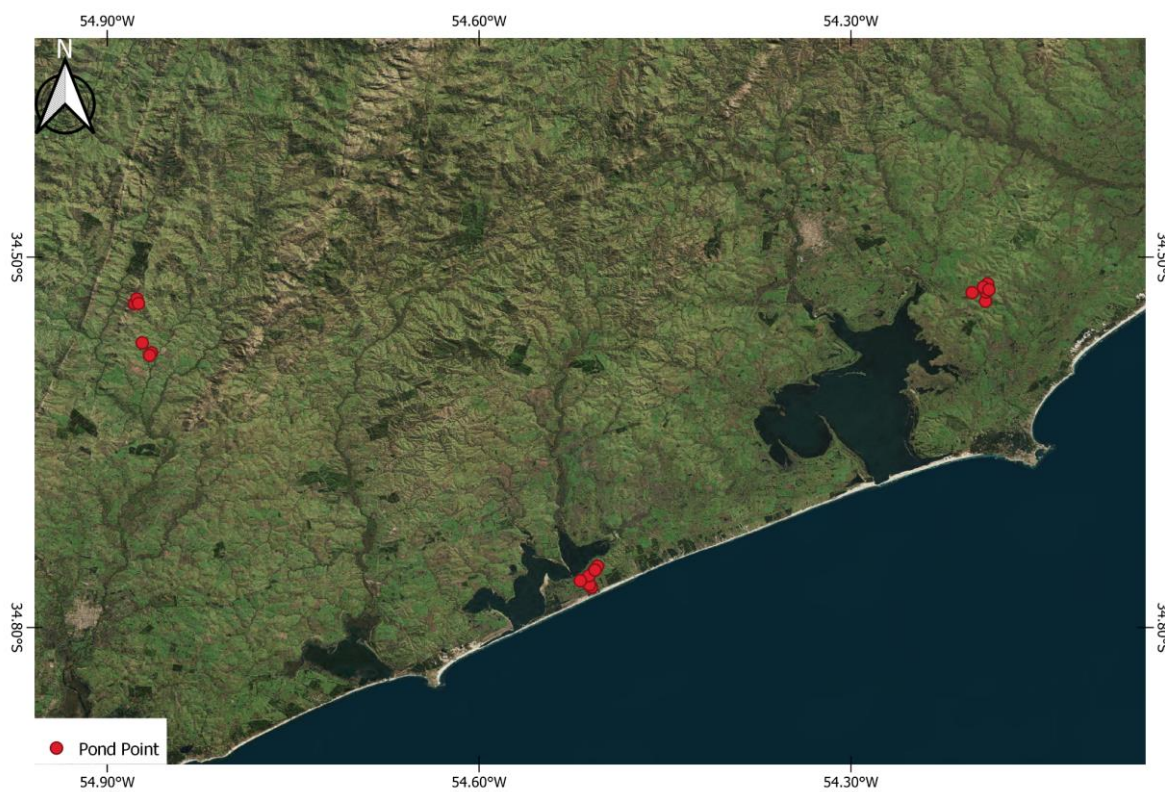

Figure 22. Spatial distribution of the ponds in the Uruguay

A brief information for ponds from the partners of PONDERFUL is presented in Table 5. Number of demo ponds and other common attributes are presented in Table 5.

Table 5. Summary table for shared PONDERFUL ponds.

Country	No. of Demo Ponds	No. of Ponds potentially included in stratified sampling	No. of Total Ponds.	Average Area(ha)	Min. Area(ha)	Max. Area(ha)	Availability of Local Database
Denmark	64	-	64	0.077	0.003	0.795	Yes
Belgium	30	47	77	0.039	0.0078	0.258	Yes
Switzerland	261	30	277	0.145	0.0005	3.23	Yes
Spain	25	196	221	0.76	0.003	16.778	No
Germany	-	32	32	-	-	-	No
Turkey	19	69	88	0.125	0.001	1.49	Yes
United Kingdom	30	84	114	0.015	0.000598	0.07	Limited
Uruguay	19	0	19	-	-	-	-

4. Results

A web application has been developed to display spatial distribution and available information of ponds from the individual countries. The application allows users to dynamically visualize the ponds and download pond's available data and hydro period information. The view of the application is presented in Figure 23. As the database is updated, the application will be updated as well. Web application can be accessed with following link: https://ponderful.hidrosaf.com/

Figure 23. PONDERFUL web application.

Several base maps are available within the application that includes satellite imagery, OpenStreetMap, distinct boundaries, MODIS, and CORINE Land cover maps (Figure 24).
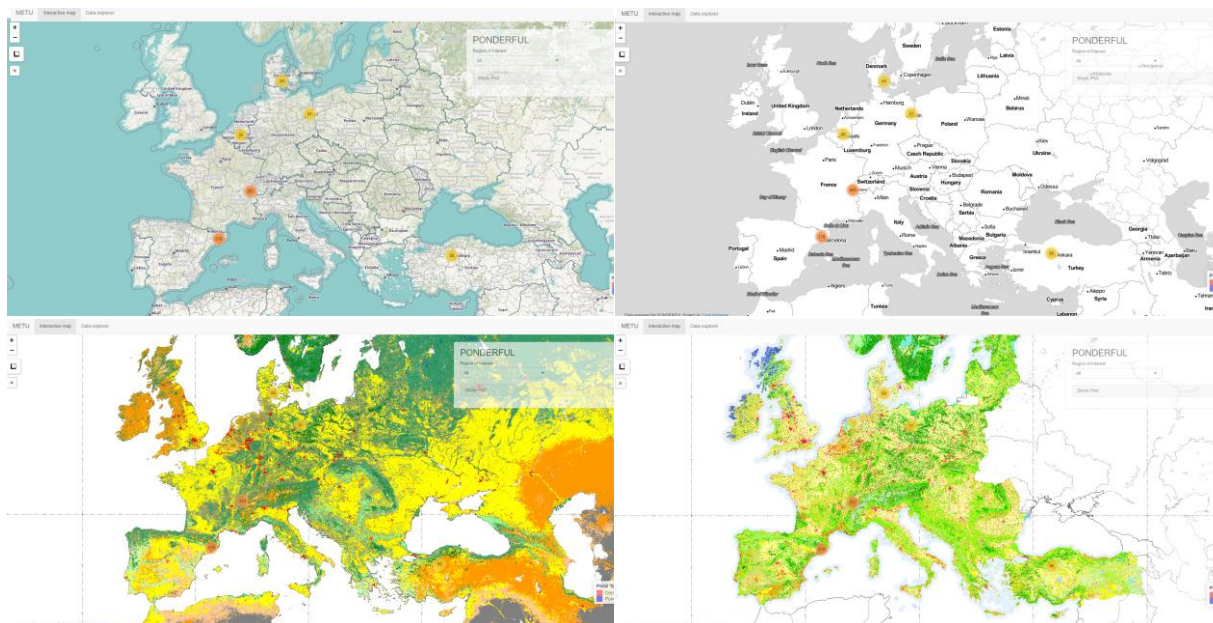
Figure 24. Base maps in the application (OSM, Boundaries, MODIS LC, Corine LC).

Information for the ponds and their hydro period can be obtained by selecting individual ponds and results will be dynamically visualized through graphs and data tables (Figure 25).
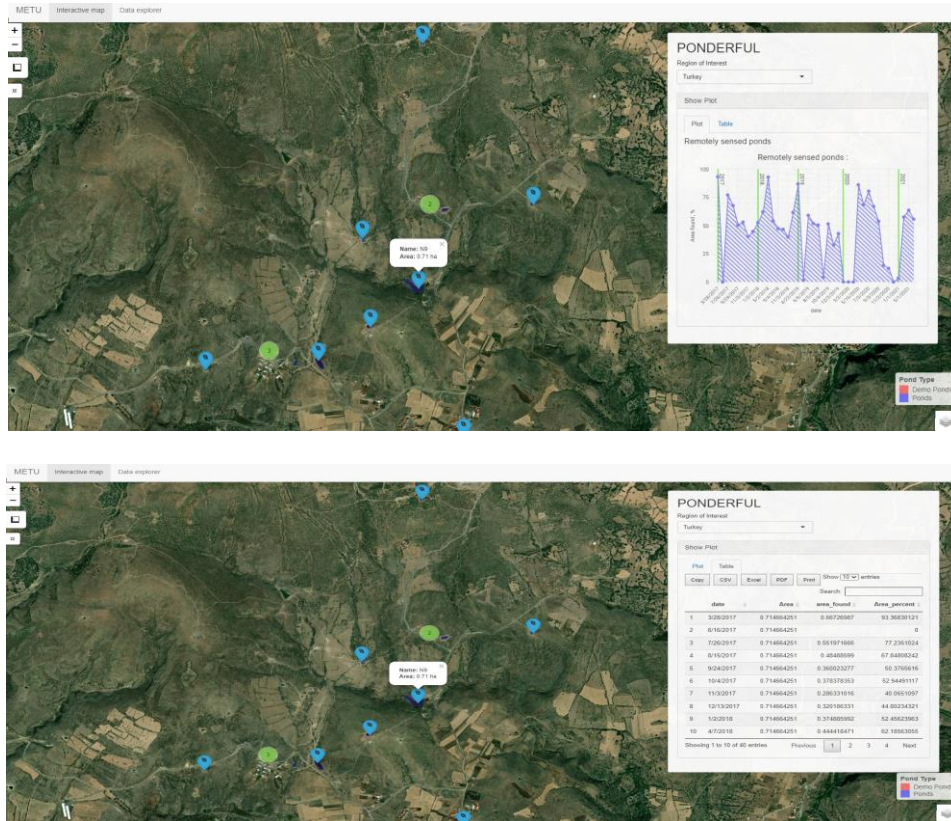

Figure 25. Hydro period information in PONDERFUL Application.

The following database is created for the ponds (Table 6). The next deliverable D3.3 (Spatial database) will include the following data.

Table 6. Attributes considered for pond's database in PONDERFUL

Name_Pond	id	Lat	Long	Demo	color	Area (km2)	Year	Country	Depth_mean (m)	Depth_max (m)	Depth_min (m)	Land Cover

5.   Conclusions

The geo-referenced data on ponds in Europe (collected under Task 2.1 in WP2 and Task 4.1 in WP4), existing spatial datasets on small water bodies in Europe, and available remote sensing products (Sentinel 1 and 2 from Copernicus and Landsat TM data) are combined to map the spatial distribution of pondscapes, assessing the density and distribution of ponds in different regions across Europe. It is presented that the global databases are too coarse to retrieve the spatial distribution of pondscapes. Medium resolution satellite images (Sentinel and Landsat) have limitations in mapping the ponds with a surface area less than 0.5 ha. Therefore, it is crucial to obtain the ponds from local databases. A web application is developed to present the ponds and their characteristics. The web application presents the ponds that are selected for stratified sampling and demo ponds. Depending on the availability of the ponds from local databases, those ones will be included in the web application.

6.   References

Nery, F. (2020). WISE WFD reference spatial data sets. Technical Report. Version 1.4.

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