Funded by
the European Union

WP2

Deliverable No.2.1:

Data inventory and evaluation of open Copernicus services and EO data

Authors: Silvia Huber, Emma Dekeyser, Rolf Wilting

Co-Authors: Rasmus Reeh, Antonia Shalamanova, Aleksandar Petrov, Nora Van Cauwenbergh and Graeme Woodsworth

Disclaimer

Grant Agreement No. **101082551**	Acronym **100KTREEs**		
Full Title	Decision toolbox for cities to improve air quality, biodiversity, human wellbeing and reduce climate risks by planting more trees.		
Topic	**EUSPA-HE-2021-SPACE-02-05** EGNSS and Copernicus for applications fostering the European Green Deal		
Funding scheme	Horizon: EUSPA-2021-SPACE		
Start Date	December 1st, 2022		
Duration	36 months		
Project URL	https://www.100ktrees.eu/		
Project Coordinator	DHI		
Deliverable	D2.1 – Data inventory and evaluation of open Copernicus services and EO data		
Work Package	WP2 – Copernicus Uptake and Spatial Data Lab		
		Version	1.0
Actual Delivery Date	23/05/2023>		
Nature		Dissemination Level	PU
Lead Beneficiary	DHI		
Authors and Co-Authors	Silvia Huber [DHI], Emma Dekeyser [ES1], Rolf Wilting [ES2], Rasmus Reeh [URD], Antonia Shalamanova [SDA], Aleksandar Petrov [OTF] Nora Van Cauwenbergh [VUB] and Graeme Woodsworth [BitaGreen]		
Quality Reviewer(s):	Lars B. Hansen [DHI]		

Funded by the European Union

Keywords	Copernicus, Orthophotos, geospatial, Earth Observation

Funded by the European Union

Document history

Ver.	Date	Description	Author(s) name
0.1	11-04-2023	ToC	Silvia Huber [DHI]
0.2	12-04-2023	First draft	Silvia Huber [DHI]
0.3	08-05-2023	Final draft	Silvia Huber [DHI], Emma Dekeyser [ES1], Rolf Wilting [ES2]
0.4	12-05-2023	Critical review	Rasmus Reeh [URD]
0.5	15-05-2023	Minor changes	Silvia Huber [DHI], Rolf Wilting [ES2]
0.6	23-05-2023	Quality check	Lars B. Hansen [DHI]
1.0	24-05-2023	Final version	Silvia Huber [DHI]

Funded by the European Union

Participants

No.	Participant Name	Short Name	Country Code	Logo
1	DHI (coordinator)	DHI	DK	
2	Sofia Development Association	SDA	BG	
3	Eurosense Belfotop	ES1	BE	
3.1	Eurosense GMBH	ES2	D	
4	EcoTree	ECO	FR	
5	Geographical Information Systems Int. Group	GSG	IT	
6	Vrije Universiteit Brussel/Bitagreen	VUB	BE	
7	OneTree Foundation (EdnoDarvo)	OTF	BG	
8	CWare (project lead)	CWR	DK	
9	UrbanDigital	URD	DK	
10	NDConsult Ltd (associated partner)	NDC	UK	

Funded by the European Union

Table of content

Funded by the European Union

List of Acronyms

EC	European Commission
EO	Earth Observation
PU	Public
T	Task
WP	Work Package

Funded by the European Union

Executive Summary

Deliverable 2.1 **Data inventory and evaluation of open Copernicus services and EO data** summarises all required geospatial data[1] for the two pilot cases Copenhagen (Denmark) and Sofia (Bulgaria) Metropolitan areas to apply the 100KTREES toolbox and in addition indicates data gaps. The inventory is presented as a data table (spreadsheet format) and basically structured into three tables, one for each of the two pilot cases (Copenhagen and Sofia) listing specific, high resolution geospatial data for the two municipalities and a third sheet listing more generic Copernicus and other free Earth Observation (EO) data and services, mostly needed for the modelling tasks performed in WP4, but also useful for geographically upscaling the toolbox to other urban areas with limited high spatial resolution data availability.

The inventory was compiled based on inputs from UrbanDigital and the Sofia Development Association, two partners in the consortium who represent the two pilot cities in this project. In addition, an extensive desktop research was conducted to supplement the inventory with additional information and where needed data providers have been contacted to clarify access rights and conditions.

The data inventory reflects the status of required geospatial data and gaps at time of deliverable submission, May 2023.

[1] Note that tree attributes are treated separately in WP3.

Introduction

1.1 Purpose and audience of the document

The data inventory is mainly used to provide an overview of available geodata sources and to prepare the data required for the various modules of the 100KTREES toolbox and last but not least to identify data gaps. With the early due of this deliverable, these data gaps can be addressed, and strategies can be developed to fill these gaps, for example by using geospatial data with a coarser spatial resolution. In some cases, suitable geospatial data exist but access is not free and open and procedures via the representatives of the two pilot cities (Copenhagen and Sofia) need to be initiated to gain access for the project. The data inventory provides an overview and helps to keep track of all required data.

The inventory was compiled based on inputs from UrbanDigital and the Sofia Development Association, two partners in the consortium who represent the two pilot cities in this project. In addition, an extensive desktop research was conducted to supplement the inventory with additional information and where needed data providers have been contacted to clarify access rights and conditions.

The inventory reflects the status of required geospatial data and gaps at time of submission.

1.2 Relation to other activities

The figure below reports the relation of the D2.1 with the other activities of the project. Except of Task (T) 2.5 and T2.6, all the tasks shown in the figure are relevant in terms of input to the inventory. Output of D2.1 is relevant for planning and coordinating all following tasks in WP2 (T2.2-T2.6), but also feeds into work packages 3 and 4.

The data inventory of D2.1 is coordinated with D3.1. The inventory of D2.1 represents EO and satellite data sets whereas the data sets of D3.1 includes tree attributes and their urban settings.

The relation to other tasks and work packages is also described in a dedicated column in the inventory table.

Funded by the European Union

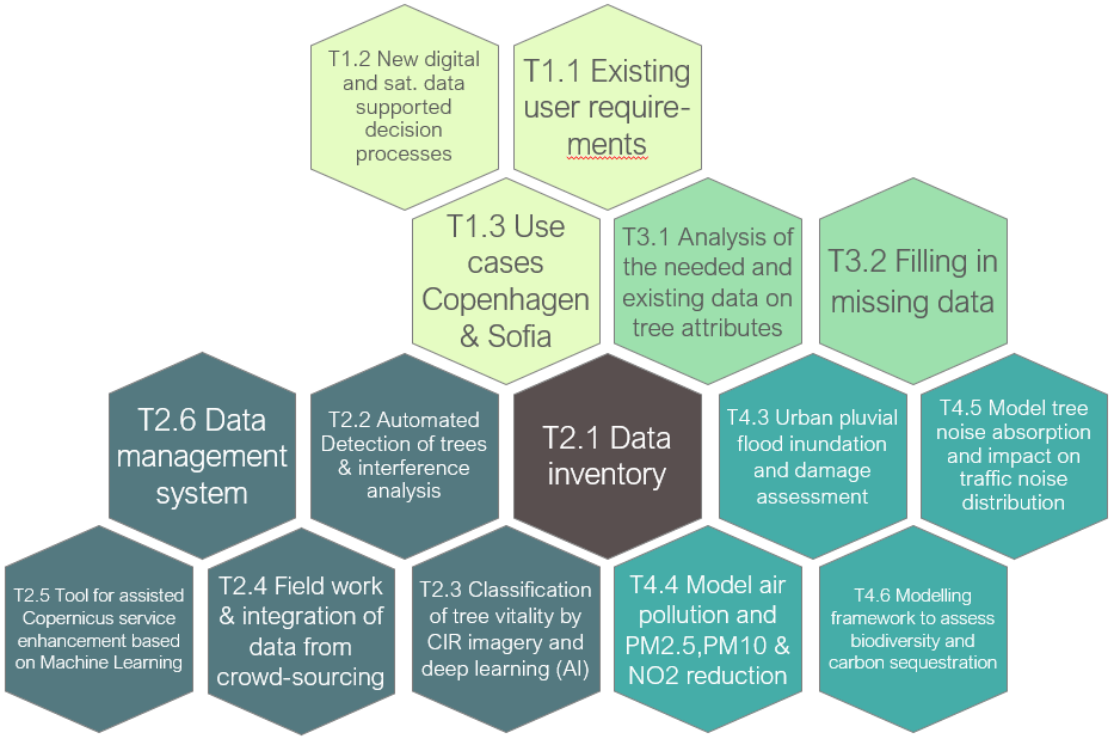

Figure 1 Tasks with relation to D2.1.

1.3 Structure of the document

The geospatial data inventory is compiled as data table in spreadsheet format with in total three sheets, the first one listing Copernicus data, the second sheet listing specific geospatial data for Copenhagen and the third sheet presenting the geospatial data inventory for Sofia.

Geospatial data inventory

The list of geospatial datasets available in large city administrations as Copenhagen and Sofia is huge. The inventory therefore was concentrated on those datasets which are needed to execute all tasks within the project. The datasets are structured into nine categories: Elevation, Environmental, Imagery, Lidar, Land Cover/Land Use, Meteorology/Climate, Socioeconomic, Vegetation and Other.

1.4 Copernicus datasets and data access

In the first sheet Copernicus data and other free and open EO data being relevant for the project and which can be linked to green urban environments are listed and pathways for data access are described. These datasets are in particular relevant for modelling tasks conducted in WP4 and for potential future use cases with limited high resolution geospatial data availability.

Data gaps are difficult to identify at time of writing since WP4 modelling tools has not started yet, which will rely on the Copernicus and other EO data.

1.5 Copenhagen data access

The second sheet lists the most relevant datasets for Copenhagen. It can be stated that there is a large database with high resolution datasets already at National level, which is mostly open and free data. Next to that there are additional datasets from the city administration.

From the list of the most crucial datasets there is only one identified data gap: the most recent summer orthophotos are under license and would need to be purchased.

1.6 Sofia data access

The third sheet lists the most relevant datasets for Sofia. In general there is less geospatial data available as OpenSource. Anyhow the investigation showed that there is valuable data available in different city administrations, but license conditions and purchasing costs need to be explored in detail.

The most critical data gap identified at this point of time is the lack of LiDAR data or 3D point clouds to automatically locate trees or do interference analysis (T2.2). A possible workaround, which will be explored further in the coming weeks, would be to derive a 3D-point cloud from stereo images by dense image correlation.

Funded by
the European Union

Conclusion

There is plenty of geospatial data incl. Copernicus and other EO data that is freely available, and new and updated datasets are released regularly in line with advances in cloud computing, machine learning, and remote sensing technology. Therefore, the inventory presented is D2.1 is only a snapshot and represents the status in May 2023.

Regarding Copernicus and other EO data, the main limitation of these data for this project with focus on urban trees, is their spatial resolution and partial lack of updating. Spatial resolutions range from 10 m to 5.5 km pixels in raster datasets. In particular meteorological datasets, such as wind speed, have coarse resolutions and the results of WP4 need to demonstrate the usefulness of these data layers in urban settings of this project. Another limitation of the datasets can be the temporal extent, not all datasets are up-to-date. Since the modelling task has not yet started in WP4, concrete data gaps or limitations are currently difficult to identify and specify. As soon as these gaps are recognizable, however, they are discussed within the project in order to find practicable solutions.

In regard to the summer orthophotos of Copenhagen there are different ways to deal with the data gap. For some tasks spring orthophotos could be used instead, but for T2.3 aerial imagery from summer with leaves on are needed for vitality assessment. For methodology development it might be sufficient to work with older imagery or with datasets from another city. Anyhow the first choice would be to purchase a single use license, which will be explored within the next partners meetings.

As an alternative, commercial very high resolution (VHR) satellite imagery can be acquired if no recent or no orthophotos at all are available. This will also provide the option to geographically upscale the urban tree vitality and location mapping globally. Currently imagery with 30x30 cm spatial resolution is available for 17 EUR/km^2.

For Sofia not all questions have been clarified yet. There is a good tree database available from OneTree Foundation. Next to that there are also other helpful datasets such as summer orthophotos and more, but some of the high resolution airborne datasets and even administrative datasets like the city cadastre are not available for free. The City of Sofia provides support to explain to the data owners the importance of the project to get access to the most important datasets for free or at least at low cost. At time of writing, clarifications are still pending.

References

NA

Funded by the European Union

Funded by
the European Union

Appendix A – Data Inventory Copernicus

	Category	Resource title	Resource type	Resource locator	Source	Spatial Resolution	Temporal Extent	Coverage	Coordinate Reference System
1	**Elevation**	Copernicus Digital Elevation Model EEA-10	raster	https://spacedata.copernicus.eu/en/web/guest/collections/copernicus-digital-elevation-model	Copernicus	10 m	2022	39 European countries including all islands of those countries plus French Overseas Departments (excluding French Overseas Territories)	EPSG: 3035 and UTM
2	**Elevation**	Copernicus Digital Elevation Model GLO-30	raster	https://sentinel.esa.int/web/sentinel/-/copernicus-dem-new-direct-data-download-access/1.3	Copernicus	30 m	2022	global	EPSG:4326
3	**Environmental**	Air quality PM2.5	raster	https://ecodatacube.eu/?base=OpenStreetMap%20(grayscale)&layer=Air%20quality%20PM2.5&zoom=4&eye=5000000&center=53.7139,17.0066&opacity=45&time=202012	EcoDataCube	1 km	Daily maps for the years 2018, 2019, and 2020.	europe	Lambert Azimuthal Equal Area
4	**Environmental**	OpenLandMap Soil Bulk Density	raster	https://opengeohub.org/about-openlandmap/	OpenGeoHub	250 m	1950-2018	global	EPSG:4326
5	**Environmental**	Soil Bulk Density	raster	https://stac.ecodatacube.eu/sol_db.od_eumap/collection.json	EcoDataCube	30 m	The maps cover the period 2000 - 2020, each map covers a certain number of years according to the following scheme: (1) 2000--2002, (2) 2002--2006, (3) 2006--2010, (4) 2010--2014, (5) 2014--2018 and (6) 2018--2020	europe	Lambert Azimuthal Equal Area

6	**Environmental**	Soil clay content		https://stac.ecodatacube.eu/sol_clay.tot.psa_eumap/collection.json	EcoDataCube	30 m	The maps cover the period 2000 - 2020, each map covers a certain number of years according to the following scheme: (1) 2000--2002, (2) 2002--2006, (3) 2006--2010, (4) 2010--2014, (5) 2014--2018 and (6) 2018--2020	europe	Lambert Azimuthal Equal Area
7	**Environmental**	Soil Hydrologic Group	raster	https://webmap.ornl.gov/ogc/dataset.jsp?ds_id=1566	NASA	250 m	These data are modeled to represent contemporary soil runoff potential. For completeness, the data were given a date range of 1900 to 2015.	global	EPSG:4326
8	**Imagery**	Very High Resolution Image Mosaic 2018 - True Colour (2m)	raster	https://land.copernicus.eu/imagery-in-situ/european-image-mosaics/very-high-resolution/very-high-resolution-image-mosaic-2018-true-colour-2m	Copernicus	2 m	2017-2019	39 European States (EEA-39) including all islands of those countries plus French Overseas Departments	EPSG:3035 (ETRS89, LAEA)

Funded by the European Union

9	**Land Cover/Land Use**	Urban Atlas LCLU 2012	vector	http://land.copernicus.eu/local/urban-atlas/urban-atlas-2012	Copernicus	Minimum Mapping Unit: Class 1: 0.25 ha Class 2-5: 1ha Minimum Mapping Width 10 m	2011-2013	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom	EPSG:3035 (ETRS89, LAEA)
10	**Land Cover/Land Use**	Urban Atlas LCLU 2018	vector	https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018	Copernicus	Minimum Mapping Unit: Class 1: 0.25 ha Class 2-5: 1ha Minimum Mapping Width: 10 m	2017-2019	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom	EPSG:3035 (ETRS89, LAEA)
11	**Land Cover/Land Use**	Urban Atlas LCLU Change 2012-2018	vector	https://land.copernicus.eu/local/urban-atlas/urban-atlas-change-2012-2018	Copernicus	Minimum Mapping Unit: Class 1 to Class 1: 0.1 ha Class 2 - 5 to Class 1: 0.1 ha Class 2 - 5 to Class 2 - 5: 0.25 ha Class 1 to Class 2 - 5: 0.25 ha Minimum Mapping Width: 10 m	2011-2019	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom	EPSG:3035 (ETRS89, LAEA)

Funded by the European Union

12	**Land Cover/Land Use**	Urban Atlas: Street Tree Layer (STL) 20	vector	http://land.copernicus.eu/local/urban-atlas/street-tree-layer-stl/view	Copernicus	Minimum Mapping Unit: 500 m² Minimum Mapping Width: 10 m	2011-2013	Austria, Belgium, Bulgaria, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom	EPSG:3035 (ETRS89, LAEA)
13	**Land Cover/Land Use**	ESA WorldCover	raster	https://esa-worldcover.org/en/data-access	European Space Agency	10 m	2020-2021	global	EPSG:4326
14	**Meteorology/Climate**	air temperature specific humidity relative humidity wind speed	raster	https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-urban-climate-cities?tab=form	Copernicus Climate Change S	100 m	2008-2017	100 European cities, including Sofia and Copenhagen	

Funded by the European Union

15	**Meteorology/Climate**	wind speed wind direction	raster	https://globalwindatlas.info/en	Global Wind Atlas	250m	Mean 2008-2017.	global	
16	**Meteorology/Climate**	wind velocity wind direction	raster	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-uerra-europe-single-levels?tab=overview	Copernicus Climate Change S	5.5km	1961-2019	Europe (The domain spans from northern Africa beyond the northern tip of Scandinavia. In the west it ranges far into the Atlantic ocean and in the east it reaches to the Ural.) MESCAN-SURFEX surface analysis is 5.5km*5.5km; In general, data is stored with hourly resolution for the UERRA-HARMONIE system	EPSG:9802
17	**Meteorology/Climate**	land surface temperature	raster	https://www.usgs.gov/landsat-missions/landsat-collection-2-surface-temperature	NASA	30 m	2013-present	global	EPSG:4326
18	**Socioeconomic**	Urban Atlas - Building Height 2012	raster	https://land.copernicus.eu/local/urban-atlas/building-height-2012	Copernicus	10 m	2011-2014	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Lithuania, Luxembourg, Malta, Moldova Republic of, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom	EPSG:3035 (ETRS89, LAEA)
19	**Socioeconomic**	High Resolution Population Density Maps	raster	https://dataforgood.facebook.com/dfg/tools/high-resolution-population-density-maps	Meta	30 m	2020	global	EPSG:4326

Funded by the European Union

20	**Vegetation**	Urban Atlas: Street Tree Layer (STL) 2018	vector	https://land.copernicus.eu/local/urban-atlas/street-tree-layer-stl-2018	Copernicus	Minimum Mapping Unit: 500 m² Minimum Mapping Width: 10 m	2017-2018	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom	EPSG:3035 (ETRS89, LAEA)
21	**Vegetation**	Leaf Area Index	raster	https://land.copernicus.eu/global/products/lai	Copernicus	300m	2014-present	global	regular latitude/longitude grid (plate carrée) with the ellipsoid WGS 1984
22	**Vegetation**	Leaf Area Index Normalized Difference Vegetation Index	raster	https://land.copernicus.eu/pan-european/biophysical-parameters/high-resolution-vegetation-phenology-and-productivity/data-access-hr-vpp	Copernicus	10 m	2017-2021	EEA38+UK region (33 member countries and 6 cooperating countries)	Sentinel-2 UTM tile grid
23	**Vegetation**	Potential Evapotranspiration	raster	https://cgiarcsi.community/2019/01/24/global-aridity-index-and-potential-evapotranspiration-climate-database-v3/	CGIAR Consortium for Spatial Information	30 arc-seconds (~1 km at equator)	1970-2000	global	EPSG:4326
24	**Vegetation**	Evapotranspiration	raster	https://lpdaac.usgs.gov/products/mod16a2v061/	USGS	500m	2001-present	global	Sinusoidal

Funded by the European Union

	Description	Lineage	Comment	Data format	Open source/on request	Relevant to WPs/Task(s)
1	Digital Surface Model (DSM) that represents the surface of the Earth including buildings, infrastructure and vegetation. (Access limited, see comments)		Access limited to Space research projects (EU funded), Non-space research projects (EU funded), EU institutions, Copernicus Services, Copernicus operators	raster	On request (see comments)	WP4
2	Digital Surface Model (DSM) that represents the surface of the Earth including buildings, infrastructure and vegetation			raster	Open source	WP4
3	Monthly PM2.5 maps aggregated from the daily PM2.5 predictions. The data source used to generate this dataset are daily Aerosol Optical Depth (AOD) at 550 nm with 1 km spatial resolution from GHADA (https://zenodo.org/record/5675427), meteorological data from ECMWF (https://cds.climate.copernicus.eu/), NDVI from MODIS MOD13A3 product and elevations from the worldwide digital surface model of the Japan Aerospace Exploration Agency (JAXA) (https://www.eorc.jaxa.jp/ALOS/). NASA's Aerosols Robotic Network (AERONET) ground measurements were used to validate this dataset.			raster	Open source	T4.4
4	Soil bulk density (fine earth) 10 x kg / m^3 at 6 standard depths (0, 10, 30, 60, 100 and 200 cm) at 250 m resolution.			raster	Open source	WP4
5	Soil bulk density in 10 kg / m-cubic [10 kg/m3] at 0, 30, 60, 100 cm Raster values represent various soil properties soil carbon (g/kg), soil pH, bulk density, sand content and clay content. Predictions of soil properties were generated by using legacy soil samples and profiles for Europe, primarily from LUCAS soil, GEMAS and national soil profile databases, most importantly BZE LW German national soil profile DB. Points were overlay using spacetime reference (latitutude, longitude, year of sampling) versus some 220 time-series and static layers representing soil forming factors: climate, relief, surface reflectance, vegetation indices, hydrological indices. Ensemble Machine Learning models were fitted per soil property for the whole spacetime cube (2000-2020) and then used to predict values at 4 standard depths. For each pixel we also provide prediction error.			raster	Open source	WP4

Funded by the European Union

6	Soil clay content in weigth fraction [%] at 0, 30, 60, 100 cm Predictions of soil properties were generated by using legacy soil samples and profiles for Europe, primarily from LUCAS soil, GEMAS and national soil profile databases, most importantly BZE LW German national soil profile DB. Points were overlay using spacetime reference (latitutude, longitude, year of sampling) versus some 220 time-series and static layers representing soil forming factors: climate, relief, surface reflectance, vegetation indices, hydrological indices. Ensemble Machine Learning models were fitted per soil property for the whole spacetime cube (2000-2020) and then used to predict values at 4 standard depths. For each pixel we also provide prediction error.				Open source	WP4
7	This dataset - HYSOGs250m - represents a globally consistent, gridded dataset of hydrologic soil groups (HSGs) with a geographical resolution of 1/480 decimal degrees, corresponding to a projected resolution of approximately 250-m. These data were developed to support USDA-based curve-number runoff modeling at regional and continental scales. Classification of HSGs was derived from soil texture classes and depth to bedrock provided by the Food and Agriculture Organization soilGrids250m system. Ref.: Ross, C.W., L. Prihodko, J. Anchang, S. Kumar, W. Ji, and N.P. Hanan. 2018. HYSOGs250m, global gridded hydrologic soil groups for curve-number-based runoff modeling. Scientific Data 5, 180091. https://doi.org/10.1038/sdata.2018.91			raster	Open source	WP4
8	VHR 2018 mosaic dataset provides one cloud-free VHR optical coverage acquired within predefined windows corresponding to the vegetation season in 2017-2018-2019. Prime Missions: Pléiades 1A & 1B, SuperView-1, Kompsat-3/3A and PlanetScope Back-up Missions: Spot-6/7 (GSD 4m), TripleSat and Deimos-2. Spatial Resolution/Spectral Resolution: VHR multispectral products (with an instrument GSD resolution from 2 meters to maximum 4 meters) Spectral bands (for all selected missions): Blue, Green, Red, NIR	The input data consists of a mix of Pleiades, SPOT, DOVE, Kompsat-4, Deimos-2, SuperView, and TripleSat images. The processing steps were as follows: 1. Resampling of all data to common resolution (2m) 2. Pre-normalization of DOVE frames 3. Merging of tiled datasets, such as DOVE frames and large SPOT images. 5. Watershed segmentation on the morphological gradient to create seamlines. 6. Cropping against seamlines and cloud-optimization for easy presentation. The list of steps outline above was	Not yet validated Public access limited according to Article 13(1)(e) of the INSPIRE Directive This dataset is based on inputs from several Copernicus Contributing Missions. Hence, the following license conditions apply: ESA-User license for the use of Copernicus Contributing Missions data - Data Warehouse phase 2 (2014-2020): https://spacedata.copernicus.eu/documents/20126/0/CSCDA_ESA_User_Licence_last_uploaded_2020_02_10.pdf/b879907e-bd00-688e-bf42-bf27a00d70cb?t=1581335391752	raster	Open source	WP2

Funded by the European Union

9	The European Urban Atlas provides inter-comparable, high-resolution land use and land cover data for 785 Functional Urban Area (FUA) for the 2012 reference year in EEA39 countries. The spatial data can be downloaded together with a map for each FUA covered and a report with the metadata for the respective area. Urban Atlas is a joint initiative of the Commission Directorate-General for Regional and Urban Policy and the Directorate-General for Enterprise and Industry in the frame of the EU Copernicus programme, with the support of the European Space Agency and the European Environment Agency.	The Urban Atlas is mainly based on the combination of (statistical) image classification and visual interpretation of Very High Resolution (VHR) satellite imagery. Multispectral SPOT 5 & 6 and Formosat-2 pan-sharpened imagery with a 2 to 2.5m spatial resolution is used as input data. The built-up classes are combined with density information on the level of sealed soil derived from the High Resolution Layer imperviousness to provide more detail in the density of the urban fabric. Finally, the Urban Atlas product is complemented and enriched with functional information (road network, services, utilities etc...) using ancillary data sources such as local city maps or online map services. During the mapping campaign for the update of Urban Atlas 2018, the LCLU status product of Urban Atlas 2012 was revised. Version 021 marks the new revised FUAs with the population estimates added as attribute Pop2012.		vector	Open source	WP2
10	Urban Atlas 2018 provides reliable, inter-comparable, high-resolution land use and land cover data with integrated population estimates for 788 Functional Urban Areas (FUA) with more than 50,000 inhabitants for the 2018 reference year in EEA38 countries (EU, EFTA, Western Balkans countries, as well as Turkey) and the United Kingdom. Urban Atlas is a joint initiative of the Commission Directorate-General for Regional and Urban Policy and the Directorate-General for Defence Industry and Space (DEFIS) in the frame of the EU Copernicus programme, with the support of the European Space Agency and the European Environment Agency.	Version **v013** marks the Functional Urban Areas (FUA) where population estimates for reference year 2018 has been added to each polygon in the attribute table as *Pop2018*. Two FUAs (FR030L1 - Fort De France, FR028L1 - Saint Denis) are still in version v012 since no population estimates are available. Cartography based on satellite images Interpretation (Pléiades, KOMPSAT, Planet, SPOT6, SuperView, etc. - resolution 2 or 4 meters) Use of ancillary data (Google Earth, OpenStreet Map). Production land use/cover maps for Functional Urban Area in Europe.		vector	Open source	WP2 WP4
11	The European Urban Atlas provides reliable, inter-comparable, high-resolution land use and land cover data for 785 Functional Urban Area (FUA) for the 2018 reference year in EEA39 countries. The spatial data can be downloaded together with a map for each FUA covered and a report with the metadata for the respective area. Urban Atlas is a joint initiative of the Commission Directorate-General for Regional and Urban Policy and the Directorate-General for Enterprise and Industry in the frame of the EU Copernicus programme, with the support of the European Space Agency and the European Environment Agency. https://land.copernicus.eu/user-corner/technical-library/urban_atlas_2012_2018_mapping_guide	Cartography based on satellite images Interpretation (2012: SPOT 5 or ALOS - resolution 2,5 meters ; 2018: Pléiades, KOMPSAT, Planet, SPOT 6, SuperView, etc. - resolution 2 or 4 meters). Use of ancillary data (Google Earth, OpenStreet Map). Production land use/cover maps for Functional Urban Area in Europe.	Not yet validated	vector	Open source	WP2

Funded by the European Union

12	The Urban Atlas provides pan-European comparable land use and land cover data for Functional Urban Areas (FUA). The Street Tree Layer (STL) is a separate layer from the Urban Atlas 2012 LU/LC layer produced within the level 1 urban mask for each FUA. It includes contiguous rows or a patches of trees covering 500 m² or more and with a minimum width of 10 meter over "Artificial surfaces" (nomenclature class 1) inside FUA (i.e. rows of trees along the road network outside urban areas or forest adjacent to urban areas should not be included).	The Urban Atlas is mainly based on the combination of (statistical) image classification and visual interpretation of Very High Resolution (VHR) satellite imagery. Multispectral SPOT 5 & 6 and Formosat-2 pan-sharpened imagery with a 2 to 2.5m spatial resolution is used as input data. The built-up classes are combined with density information on the level of sealed soil derived from the High Resolution Layer imperviousness to provide more detail in the density of the urban fabric. Finally, the Urban Atlas product is complemented and enriched with functional information (road network, services, utilities etc...) using ancillary data sources such as local city maps or online map services.	Partially validated product; summary results available in the technical library.	vector	Open source	WP2 WP4
13	WorldCover provides the first global land cover products for 2020 and 2021 with 11 classes at 10 m resolution, developed and validated in near-real time based on Sentinel-1 and Sentinel-2 data. The discrete classification map provides 11 classes and is defined using the Land Cover Classification System (LCCS) developed by the United Nations (UN) Food and Agriculture Organization (FAO). For more information: https://esa-worldcover.s3.eu-central-1.amazonaws.com/v200/2021/docs/WorldCover_PUM_V2.0.pdf			raster	Open source	WP2
14	The dataset contains air temperature, specific humidity, relative humidity and wind speed for 100 European cities for the current climate. The data were generated using the urban climate model UrbClim, developed at VITO. This model was designed to simulate and study the urban heat island effect (UHI) and other urban climate variables at a spatial resolution of 100 metres. The unique capabilities of UrbClim allow to generate spatially explicit timeseries of hourly variables from which a variety of indicators can be retrieved in postprocessing at the scale of a city neighbourhood. For this specific dataset, the ERA5 reanalysis large-scale weather conditions are downscaled to agglomeration-scale. UrbClim then computes the impact of urban development on the most frequent weather parameters, such as temperature and humidity. The 100 European cities for the urban simulations were selected based on user requirements within the health community. Furthermore, a high spatial distribution was aimed with specific focus on Eastern European countries that often lack access to relevant information. The data was produced on behalf of the Copernicus Climate Change Service. https://confluence.ecmwf.int/display/CKB/Climate+variables+for+cities+in+Europe+from+2008+to+2017+documentation			raster	Open source	T4.4

Funded by the European Union

15	The Global Wind Atlas is a free, web-based application developed to help policymakers, planners, and investors identify high-wind areas for wind power generation virtually anywhere in the world, and then perform preliminary calculations. The Global Wind Atlas facilitates online queries and provides freely downloadable datasets based on the latest input data and modeling methodologies			raster	Open source	T4.4
16	This UERRA dataset contains analyses of surface and near-surface essential climate variables from UERRA-HARMONIE and MESCAN-SURFEX systems. Forecasts up to 30 hours initialised from the analyses at 00 and 12 UTC are available only through the CDS-API (see Documentation). UERRA-HARMONIE is a 3-dimensional variational data assimilation system, while MESCAN-SURFEX is a complementary surface analysis system. Using the Optimal Interpolation method, MESCAN provides the best estimate of daily accumulated precipitation and six-hourly air temperature and relative humidity at 2 meters above the model topography.			raster	Open source	T4.4
17	The surface temperature product is generated from the Landsat Collection 2 Level-1 thermal infrared bands, Top of Atmosphere (TOA) reflectance, TOA brightness temperature, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Emissivity Database (GED) data, ASTER Normalized Difference Vegetation Index (NDVI) data, and atmospheric profiles of			raster	Open source	WP2 WP4
18	Urban Atlas is a joint initiative of the European Commission Directorate-General for Regional and Urban Policy and the Directorate-General for Defence Industry and Space (DEFIS) in the frame of the EU Copernicus programme, with the support of the European Space Agency and the European Environment Agency.	This product is generated based on satellite information acquired as close as possible to the defined reference year. Based on these images a digital surface model is generated. Afterwards a digital terrain model is derived from the DSM with different filter algorithms and the assistance of Urban Atlas 2012 datasets. The calculation of the normalized DSM is done by a simple subtraction of the DTM from the DSM. The final product is then clipped based on UA 2012 building blocks and fully quality controlled.		raster	Open source	WP4
19	Seven maps/datasets for the distribution of various populations: (1) Overall population density (2) Women (3) Men (4) Children (ages 0-5) (5) Youth (ages 15-24) (6) Elderly (ages 60+) (7) Women of reproductive age (ages 15-49).			raster	Open source	

Funded by the European Union

20	Urban Atlas is a joint initiative of the European Commission Directorate-General for Regional and Urban Policy and the Directorate-General for Enterprise and Industry in the frame of the EU Copernicus programme, with the support of the European Space Agency and the European Environment Agency.	Cartography based on satellite images Interpretation (Pléiades, KOMPSAT, Planet, SPOT6, SuperView, etc. - resolution 2 or 4 meters) se of ancillary data (Google Earth, OpenStreet Map). Production Street Tree Layer for Functional Urban Area in Europe. STL:1 - Stree Tree	Not yet validated	vector	Open source	WP2 WP4
21	leaf area index (LAI), which is a biophysical parameter defined as the one-sided leaf surface area over the corresponding ground area. Daily LAI 300m is estimated by applying a Neural Network on instantaneous Top-of-Canopy reflectances from Sentinel-3 OLCI (v1.1 products), or daily Top-of-Aerosol input reflectances from PROBA-V (v1.0). Temporal smoothing and small gap filling is applied to the instantaneous LAI estimates, discriminating Evergreen Broadleaf Forest (EBF) and no-EBF pixels. Temporal compositing is adapted to provide a near-real time (10-daily) estimate and successive updated estimates until a consolidated value is reached after about 2 months.			raster	Open source	WP4
22	NDVI and LAI for each pixel for the respective observation day https://land.copernicus.eu/pan-european/biophysical-parameters/high-resolution-vegetation-phenology-and-productivity/#HRVPP_Product_summary			raster	Open source	WP4
23	Global raster data for the 1970-2000 period, related to evapotranspiration processes and rainfall deficit for potential vegetative growth, based on the implementation of the FA0-56 Penman-Monteith Reference Evapotranspiration (ET0) equation.			raster	Open source	WP4
24	The Terra Moderate Resolution Imaging Spectroradiometer (MODIS) MOD16A2 Version 6.1 Evapotranspiration/Latent Heat Flux product is an 8-day composite dataset produced at 500 meter (m) pixel resolution. The algorithm used for the MOD16 data product collection is based on the logic of the Penman-Monteith equation, which includes inputs of daily meteorological reanalysis data along with MODIS remotely sensed data products such as vegetation property dynamics, albedo, and land cover. Provided in the MOD16A2 product are layers for composited Evapotranspiration (ET), Latent Heat Flux (LE), Potential ET (PET) and Potential LE (PLE) along with a quality control layer. Two low resolution browse images, ET and LE, are also available for each MOD16A2 granule. The pixel values for the two Evapotranspiration layers (ET and PET) are the sum of all eight days within the composite period and the pixel values for the two Latent Heat layers (LE and PLE) are the average of all eight days within the composite period. Note that the last 8-day composition period of each year is a 5 or 6 day composite period, depending on			raster	Open source	WP4

Appendix B – Data Inventory Copenhagen

	Category	Resource title	Resource type	Resource locator	Source	Spatial Resolution	Temporal Extent	Coverage	Coordinate Reference System
1	**Elevation**	Denmark's Elevation Model - Surface	raster	https://dataforsyningen.dk/data/928	SDFE (Danish Agency for Data supply and Infrastructure)	0,4 m ; Accuracy: Horizontal 0.15 meters, Vertical 0.05 meters.	Derived from Denmark's Elevation Model - Punktsky	Denmark	EPSG:25832
2	**Elevation**	Denmark's Elevation Model - Terrain	raster	https://dataforsyningen.dk/data/930	SDFE (Danish Agency for Data supply and Infrastructure)	0,4 m; Accuracy: Horizontal 0.15 meters, Vertical 0.05 meters.	Derived from Denmark's Elevation Model - Punktsky	Denmark	EPSG:25832
3	**Elevation**	Denmark's Elevation Model - Punktsky	LiDAR point cloud	https://dataforsyningen.dk/data/3931	SDFE (Danish Agency for Data supply and Infrastructure)	4-5 points/m2 for 2014-2015 data 8 points/m2 for data collected from 2018 onwards; Accuracy: Horizontal 0.15 m, vertical 0.05 m	The height model is continuously updated, approx. 1/5 per year; last updated for Copenhagen in 2019 (6/4/2019)	Denmark	horizontal - ETS89- EPSG:25832 vertical - DVR90 - EPSG:5799
4	**Imagery**	Summer Orthophotos	raster (RGBNir)	https://dataforsyningen.dk/data/3721	GeoDenmark	typically 20 cm GSD in even years and 25 cm GSD in odd years. The pixel size for the years 1999, 2002, 2005 is 40 cm, while it is 12.5 cm for 2008.	Every year within the period May 10 - July 31. Available on Dataforsyningen website (WMS): 1999, 2002, 2005 and 2008. Last summer orthophoto for Copenhagen: 17/6/2022	Denmark	EPSG: 25832 (UTM32_ETRS89)

Funded by the European Union

5	**Imagery**	Spring Orthophotos	raster (RGBNir)	https://dataforsyningen.dk/data/981	GeoDenmark	The resolution in the raw images is 16 cm GSD, with selected areas in 10 cm GSD if the municipalities order it. The pixel size is respectively 12.5 cm	March 8 - May 1, 2004 - 2022. Last spring orthophoto for Copenhagen: 16/4/2022	Denmark	EPSG: 25832 (UTM32_ETRS89)
6	**Land Cover/Land Use**	Land cover and use	vector	https://dataforsyningen.dk/data/996	GeoDenmark - adapted to INSPIRE	MMU Vegetation: 0.1 - 2.5 ha Waters: 0.5 - 2 ha Urban areas: 0.5 - 2 ha Agricultural areas: 0.5 - 2 ha Grasslands: 0.5 - 2 ha Others: 2 ha	Data available via download is updated quarterly in the months of March, June, September and December.	Denmark	EPSG:3044 EPSG:4097
7	**Land Cover/Land Use**	Basemap03 land use / land cover map	vector or raster	https://envs.au.dk/faglige-omraader/samfund-miljoe-og-ressourcer/arealanvendelse-og-gis/basemap	Aarhus Universitet	10 m	2011, 2016, 2018	Denmark	
8	**Land Cover/Land Use**	Basemap04 land use / land cover map	vector or raster	https://envs.au.dk/faglige-omraader/samfund-miljoe-og-ressourcer/arealanvendelse-og-gis/basemap	Aarhus Universitet	10 m	2021	Denmark	

Funded by the European Union

9	**Other**		Vector and raster	**INSPIRE - Transport network**: https://dataforsyningen.dk/data/2689 **INSPIRE - BBR buildings and homes**: https://dataforsyningen.dk/data/3829 **Nature and green areas Danmark**: https://dataforsyningen.dk/data/2683 **Air pollution**: https://www.opendata.dk/city-of-copenhagen/luftforurening **CO2accounting**: https://www.opendata.dk/city-of-copenhagen/co2-regnskab **Meteorological data:** https://confluence.govcloud.dk/display/FDAPI **Hydrological data (river bassin, floods etc.):** https://dataforsyningen.dk/data					
10	**Socioeconomic**	Geography of Denmark	vector	https://dataforsyningen.dk/data/3563	GeoDenmark	Minimum mapping unit: buildings: 10m2 forest: 2500 m2 Road minimum mapping width: 1 m & Accuracy: Urban area: XY=10 cm. Z=15 cm. Land area: XY=75 cm. Z=75 cm.	The data set is systematically maintained based on annual aerial photographs of all of Denmark in the spring before leaf spring. The municipalities contribute with daily updates of buildings and roads when they deal with these matters. GeoDanmark data is systematically maintained according to two methods: Designated updating and total updating. One region in Denmark is fully updated, while the other 4 are updated by designated update. It takes turns which region is fully updated, so there is a 5 year cycle for this. The designated update shall update all the designated sites. At the total update, all the designated sites are updated AS well as by actively examining whether other objects and other places also need to be updated.	Denmark	UTM zone 32/ETRS89 for plan registration DVR90 for height registration
11	**Socioeconomic**	Land registry card - Cadaster	vector	https://dataforsyningen.dk/data/1014	GeoData Agency		The cadastral map at the Geodata Agency is continuously updated as part of the registration of cadastral changes, where the practicing surveyors send measurements to new and already existing boundaries and lines.	Denmark	UTM zone 32/ETRS89
12	**Socioeconomic**	3D City Model	CAD	https://www.opendata.dk/city-of-copenhagen/kobenhavn-3d-bymodel	Commune of Copenhagen		2013	Copenhagen	
13	**Vegetation**	Municipal tree dataset	Vector	https://www.opendata.dk/city-of-copenhagen/trae-basis-kommunale-traeer	Commune of Copenhagen			Copenhagen	EPSG:25832

Funded by the European Union

		Lineage	Comment	Data format	Open source/on request	Relevant to WPs/Task(s)
1	DHM/Surface is based on all classes from the point cloud that are considered to belong to the surface. Points classified as high voltage line and noise are filtered out of the model. The point cloud is converted to a grid with a size of 0.4 meters. Specified accuracies: Horizontal 0.15 meters, Vertical 0.05 meters. Accuracies stated as RMS and determined on well-defined surfaces. DHM/Surface_shadowmap is a derivative of DHM/Surface. The 3-dimensional effect is produced by simulating a light source from a north-west direction and calculating which areas are in light or shadow and how much.	dervied from LiDAR point cloud data found at https://dataforsyningen.dk/data/3931		WCS, WMS, WMTS, GEOTIFF, DAF	Open source	T2.2: automatic tree detection
2	DHM/Punktsky is filtered so that only points that are classified as located on terrain are included. Points classified as building, vegetation and other objects are removed from the model. The point cloud is converted to a grid with a size of 0.4 meters. Specified accuracies: Horizontal 0.15 meters, Vertical 0.05 meters. Accuracies stated as RMS and determined on well-defined surfaces. DHM/Terræn_shadow map is a derivative product of DHM/Terræn. The 3-dimensional effect is produced by simulating a light source from a north-west direction and calculating which areas are in light or shadow and how much.	dervied from LiDAR point cloud data found at https://dataforsyningen.dk/data/3931		WCS/WMS/WMTS/GEO TIFF/DAF	Open source	T2.2: automatic tree detection
3	Denmark's Altitude Model (DHM) is collected by laser scanning from aircraft (LiDAR). The height model is continuously updated, approx. 1/5 per year. The DHM origin layer contains information about when an area has flown. The collected point cloud has an average density of 4-5 points/m2 for data collected in 2014/15 and 8 points/m2 for data from 2018 onwards. The point cloud is classified (terrain, building, vegetation, bridge, ...). The uniformity of DHM/Point Cloud depends on different physical conditions, including the nature of the surface (e.g. reflectivity, humidity at the time of scanning, etc.). Flight altitude and scanning frequency are adapted so that the point cloud is as uniform as possible. However, areas covered by water that has the character of lake or sea and non-reflective surfaces have a lower point density. Subtleties: Horizontal 0.15 m., vertical 0.05 m. Accuracies stated as RMS and determined on well-defined surfaces.		technical specifications can be found at https://dataforsyningen.dk/asset/PDF/produkt_dokumentation/dhm-prodspec-v1.0.0.pdf	.LAZ, downloadable in 10 x 10 km tile = 18,3 GB	Open source	T2.2: automatic tree detection
4	The accuracy is better than 2 pixels RMSE. Summer orthophotos are typically photographed from May 10 to July 31 each year. The period can be extended for periods of 2 weeks if it cannot be completed within the original photo window. Denmark is divided into 53 geographical blocks, which are divided into typically 3 lots/contracts. In even years, there are typically 8-10 public authorities participating in the procurement and in odd years typically 3 authorities. This is reflected in the resolution of Sommerortofoto, which is typically 20 cm GSD in even years and 25 cm GSD in odd years.		Sommerortofoto year 1999, 2002, 2005 and 2008 are free of charge and there is free access for all users. In order to gain access to Sommerortofoto year 2010, 2012, 2014, 2016, 2017, 2019, 2020, it is required that a 3rd party acquire the right to use Sommerortofoto by contacting those who have the ownership rights. These are typically the photo companies that did the photography. However, the Danish Agency for Agriculture and the Board for Data Supply and Infrastructure (SDFI) have ownership rights to the year 2017 and 2018. On request, SDFI can inform you which companies have ownership rights to the individual years.	WMS for the orthophotos from the year 1999, 2002, 2005 and 2008 (Open source pictures).	1999, 2002, 2005, 2008: open source (WMS). Recent summer orthophotos on request (not open source). See: https://sdfi.dk/vores-opgaver/dataindsamling/flyfotos-og-laserscanning	T2.2: automatic tree detection & T2.3: Classification of tree vitality

Funded by the European Union

5	The images are recorded from aircraft with special cameras annually before foliage in the period 1 March – 1 May. They are recorded with a length overlap of 60 % and are side overlap of 20 %. This ensures a high accuracy so that the images can be used for the production of orthophotos and updating of Geodanmark_vektor. Quickorto: The accuracy is 10 pixels RMSE. Orto_foraar_temp: The accuracy in is 2 pixels RMSE. Orto_foraar: The accuracy in is 2 pixels RMSE. Geodanmark Ortofoto is calculated on the raw images in the resolution 16 cm GSD (1 pixel corresponds to 16x16 cm on the ground surface). By default, the images are recorded in 15 cm Ground Sample Distance (GSD), after which the orthophoto is resampled to the pixel size of 12.5 cm. However, municipalities can instead choose to have images recorded in 10 cm GSD, which is produced for orthophoto in the pixel size 10.0 cm. Orthophotos are produced as 4-channel RGBNir, 32 bit, the projection UTM32_ETRS89, DVR90 (EPSG: 25832). 10 cm GSD means that each pixel represents an area of 10 x 10 cm on land.			2022: DAF, FTP, ECW (downloadable by 10 x 10 km tile = 2,1 GB) - Historical data (<2022): WMS/WMTS	Open source/on request	(T2.3: Classification of tree vitality, depending on periode)
6	Data is extracted from GeoDanmark and adapted to the INSPIRE data specification. Land Cover consists of a collection of units, these can be points, polygons, or raster cells (resulting in two core models, one for vector data and one for raster data). The following data has been extracted from GeoDanmark and adapted to the INSPIRE data specification Land Cover. LandCoverUnit: Town centre, Horticulture, Heath, Scrub, Vegetation, Sand, Dune, Forest, High-rise buildings, Low-rise buildings, Commercial, Technical area.			WMS, GML	Open source	T2.2 Interference analysis
7	Basemap is a national map of land use / land cover, which combines publicly available geographical information into a comprehensive land map. Basemap is a raster map with a cell size of 10 x 10 meters. The Basemap was first prepared in 2011. In 2017, DCE-Aarhus University prepared an updated version of the Basemap for Statistics Denmark, based on input data from 2016 (Basemap02) and in 2019, DCE-Aarhus University prepared an updated version of the Basemap for Statistics Denmark, based on input data from 2018 (Basemap03). Basemap is the most up-to-date national map of land use and land cover and is used by a number of different actors within research and authority services as well as private companies. Statistics Denmark uses the map for Denmark's green national accounts and for national area statistics. The card's strength is that a documented and transparent method is used. In addition, the original area class categories from the various data sources used are retained, so that it is possible for users to aggregate area classes for specific needs.			Geopackage, Geotiff	Open source	T2.2 Interference analysis
8	Basemap is a national map of land use / land cover, which combines publicly available geographical information into a comprehensive land map. Basemap is a raster map with a cell size of 10 x 10 meters. The Basemap was first prepared in 2011. In 2017, DCE-Aarhus University prepared an updated version of the Basemap for Statistics Denmark, based on input data from 2016 (Basemap02) and in 2019, DCE-Aarhus University prepared an updated version of the Basemap for Statistics Denmark, based on input data from 2018 (Basemap03). Basemap is the most up-to-date national map of land use and land cover and is used by a number of different actors within research and authority services as well as private companies. Statistics Denmark uses the map for Denmark's green national accounts			Geopackage, Geotiff	Open source	T2.2 Interference analysis

Funded by the European Union

9					Open source	T2.2 Interference analysis, WP4: Model
10	SDFI and the municipalities have agreed on the framework for a collaboration that ensures that data is maintained. This includes updating roads, buildings, streams and lakes in the map at least once a year. These elements are important because they are information that is part of case processing in many areas in municipalities and the state. This kind of updating is based on the knowledge of employees who know what reality looks like. As it is today, GeoDanmark data is mainly updated by review based on aerial photos, but it is the ambition that the contribution from the administrative update will be greater in the future. Establishment: The register has started at different times in the individual municipalities starting around 2007 and became nationwide in 2014.		Technical specifications can be found at http://geodanmark.nu/Spec6/HTML5/DK/StartHer.htm	WMS, WFS, Geopackage	Open source	T2.2: Interference analysis
11	The cadastral map is a digital, legal map that shows the registered property boundaries and rights of way. The cadastral map also shows the areas covered by peace forest, zones for beach protection and dune conservation. The cadastral map is intended to be a graphic display of the Cadastre Register, so that the individual cadastral areas (cadastral numbers, road letters, etc.) can be identified. The cadastral map at the Geodata Agency is continuously updated as part of the registration of cadastral changes, where the practicing surveyors send measurements to new and already existing boundaries and lines.			WFS, WMS, Geopackage, DXF	Open source	T2.2: Interference analysis
12	3D model of both buildings and terrain in the City of Copenhagen. The model was created in 2013			DWG, DGN, DXF	Open source	T2.2: Interference analysis
13	Master register containing all municipal trees (e.g. park trees, natural trees, street trees as well as trees at risk, trees with bacterial cancer and felled trees) on municipal roads. Existing trees on municipal roads as well as 'street trees in the park' close to municipal roads also form the basis for the calculation of the roads' potential for new trees in relation to the effort of around 100,000 trees.			GeoJSON, CSV, SHP	Open source	T2.2 Interference analysis

Funded by the European Union

Appendix C – Data Inventory Sofia

	Category	Resource title	Resource type	Resource locator	Source	Spatial Resolution	Temporal Extent	Coverage	Coordinate Reference System
1	**Elevation**	Digital Terrain Model	Raster	https://api.sofiaplan.bg/datasets/543?_gl=1*mmt2il*_ga*ODQyMjk0MzkxLjE2NzM0Mzc4NjA.*_ga_V553XY2L7Y*MTY4MzAzMTcyMS4xMi4xLjE2ODMwMzE3NTAuMC4wLjA.*_ga_SKNV2TENTN*MTY4MzAzMTcyMS4yLjEuMTY4MzAzMTczMi4wLjAuMA..&_ga=2.38012896.214192657.1683029851-842294391.1673437860	Sofiaplan	4,7 m	2017	Sofia municipality	WGS 1984 UTM Zone 34N
2	**Elevation**	Digital Surface Model	Raster		N/A	N/A	N/A	N/A	N/A
3	**Environmental**	Noise map	Vector	https://api.sofiaplan.bg/datasets/69?_ga=2.82930773.214192657.1683029851-842294391.1673437860&_gl=1*hk1eiq*_ga*ODQyMjk0MzkxLjE2NzM0Mzc4NjA.*_ga_V553XY2L7Y*MTY4MzAzMTcyMS4xMi4xLjE2ODMwMzM4NDguMC4wLjA.*_ga_SKNV2TENTN*MTY4MzAzMTcyMS4yLjEuMTY4MzAzMzgyNS4wLjAuMA..	Sofiaplan		2019	Sofia municipality	WGS 1984
4	**Imagery**	Autumn orthophotos 2020 (10 cm)	Raster	https://www.gis-sofia.bg/en/services/photogrammetry/processing-aerophoto-and-satellite-imagery	GIS Sofia	Residential territories: 10 cm, non-residential territories: 15 cm	2020 - (~October)	Sofia municipality	
5	**Imagery**	Summer orthophotos 2020 (40 cm)	Raster	https://www.mzh.government.bg/media/filer_public/2023/04/24/obshchi_tseni_kartni_listove_ot_tsofk.pdf https://www.mzh.government.bg/bg/politiki-i-programi/programi-za-finansirane/direktni-plashaniya/cifrova-ortofotokarta/	Eurosense, Ministry of agriculture	40 cm	2020 - (26/07 - 03/08)	Sofia municipality	

Funded by the European Union

6	**Lidar**	LiDAR-data	LiDAR (3D - point cloud)	N/A	N/A	N/A	N/A	N/A	N/A
7	**Other**	Boundaries, roads, cycle roads, foot path, public transport	Vector	http://www.isofmap.bg/ https://sofiaplan.bg/api/	Sofiaplan, GIS Sofia			Sofia municipality	WGS 1984
8	**Socioeconomic**	3D City model	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	**Socioeconomic**	Cadastral map	Vector	http://www.isofmap.bg/ https://sofiaplan.bg/api/ https://www.gis-sofia.bg/en/cadastre	Sofiaplan, GIS Sofia			Sofia municipality	
10	**Vegetation**	Tree cadaster	Vector	https://sofiaplan.bg/portfolio/trees-index/	Sofiaplan			Sofia municipality	
11	**Vegetation**	Urban Tree Database OneTree Foundation	Vector	https://ednodarvo.io/	OneTree			Sofia municipality	

Funded by the European Union

	ption	Lineage	Comment	Data format	Open source/on request	Relevant to WPs/Task(s)
1				.tif	Open source	T2.2: automatic tree detection
2	l data for Sofia available (= data gap)	N/A	N/A	N/A	N/A	T2.2: automatic tree detection
3				GeoJSON	Open source	W4 Model
4			if possible we`ll try to optain not only the 2D orthophotos, but also the original stereo images to derive a 3D point cloud as a substitute for the missing LiDAR data		On request	T2.2: automatic tree detection & T2.3: Classification of tree vitality
5					On request. Purchase via ministry of agriculture	T2.3: Classification of tree vitality, depending on period

Funded by the European Union

6	.R data for Sofia available (= data gap)	N/A	Work around planned with dense image correlation from stereo images (to be elaborated)	N/A	N/A	T2.2: automatic tree detection
7			These datasets can be found partially open source on the dataportal of Sofiaplan and on request of GIS Sofia		Partially open source (Sofiaplan) - On request (GIS Sofia)	T2.2 Interference analysis
8	model for Sofia available (= data gap)	N/A	N/A	N/A	N/A	T2.2 Interference analysis
9					On request	T2.2 Interference analysis
10	mapped in the field using high-resolution aerial imagery (3.671 ortho fotos with resolution of 10 cm²/px from autumn 2020), +- 80% accuracy •Total number of trees: 5.5 million in Sofia City Province 640 thousand in Sofia City •Derived tree information: o crown diameter o crown projection				On request	T2.2: automatic tree detection & T2.3: Classification of tree vitality
11	•Purpose: involvement of citizens in the management of urban trees •Features of this application: oAdd new features o'Knowledge section' in platform: information about tree species + characteristics + environmental requirements + potential benefits and harms => interesting WP3				Open source (display)/On request (data base)	T2.2: automatic tree detection & T2.3: Classification of tree vitality

Funded by the European Union