Data Article

Ecosystem services indicators dataset for the utilized agricultural area of the Märkisch-Oderland District-Brandenburg, Germany

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\textbf{A B S T R A C T}

The dataset of the ecosystem services provided by the agricultural areas of the Märkisch-Oderland District-Brandenburg, Germany, contains six standardised indicators of ecosystem service provision, and includes one provisioning service - i) biomass production (PRO), four regulating services - ii) water storage (WAS), iii) carbon stock total (CST), iv) carbon stock potential (CSP), v) habitat for species (HAB), and one cultural service – vi) landscape attractiveness (LAT). The indicators were built from mostly public data, including for example the CORINE Land Cover map, the GSP-FAO soil carbon stock map, and MODIS NDVI and ASTER DEM satellite images.

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## Specifications Table

| Subject          | Agricultural Sciences |
|------------------|-----------------------|
| Specific subject area | Ecosystem services provided by utilized agricultural areas |
| Type of data     | Table |
| How data were acquired | The primary data are available to users from public datasets; secondary data from the supplementary data files. Public datasets: |
| NDVI (https://lpdaacsvc.cr.usgs.gov/) |
| DTM (https://lpdaacsvc.cr.usgs.gov/) |
| CORINE Land Cover (https://land.copernicus.eu/pan-european/corine-land-cover) |
| Soil Map of Brandenburg (BUEK 300, http://www.geo.brandenburg.de/boden/) |
| Map of Soil Carbon stock (Mg ha⁻¹) 0-30 cm (GSOCmap V1.0, http://54.229.242.119/GSOCmap/) |
| Cadastral data of Brandenburg (Digitales Feldblockkataster des Landes Brandenburg 2020, DFBK²⁰/BB: https://geobroker.geobasis-bb.de/gbss.php?MODE=GetProductInformation&PRODUCTID=9e95f21f-4ecf-4682-9a44-e5f76096fa0) |
| Maps of biotopes, legally protected biotopes and FFH habitat types in Brandenburg (https://mluk.brandenburg.de/mluk/de/) |
| Supplementary data file: |
| Shape file of six ecosystem services |
| Data format | Raw and analyzed |
| Parameters for data collection | Primary data were collected in order to derive the necessary information to assess the provision of six ecosystem services by the agricultural land of the Märkisch-Oderland District in east Brandenburg, Germany: i) biomass production (PRO), ii) water storage (WAS), iii) carbon stock total (CST), iv) carbon stock potential (CSP), v) habitat for species (HAB) and vi) landscape attractiveness (LAT). |
| Description of data collection | The primary data for the ecosystem service assessment were downloaded from different sources, all freely available. |
| Data source location | The primary data sources are the following: |
| U.S. Department of the Interior-U.S. Geological Survey, URL: https://lpdaacsvc.cr.usgs.gov/appeears/ for Modis-NDVI and Aster-DTM Copernicus Land Monitoring Service, URL: https://land.copernicus.eu/pan-european/corine-land-cover for CORINE Land Cover Map |
| Brandenburg State Office for Mining, Geology and Raw Materials (LBGR) for 1:300,000 soil map, URL: http://www.geo.brandenburg.de/boden/ |
| FAO-CSP GLOSSIS - GSOCmap (v1.5.0) for the soil carbon stock (0-30 cm), URL: http://54.229.242.119/GSOCmap/ |
| Ministry for Rural Development, Environment and Agriculture of the State of Brandenburg (MLUL), for cadastral land parcels information, URL: http://geobroker.geobasis-bb.de/index.php |
| Ministry of Agriculture, Environment and Climate Protection (MLUK) of the State of Brandenburg for landscape elements, biotopes, legally protected biotopes and FFH habitat types, URL: https://mluk.brandenburg.de/mluk/de/ |
| Data accessibility | Data are hosted with the article in ESRI shape file format (ES_MOL.zip) and as CSV file in the public date repository at the Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e. V. |
| Repository name: Open Research Data, URL: http://open-research-data-zalf.ext.zalf.de/default.aspx |
| Data identification number: 10.4228/ZALF.DK.154 |
| Direct URL to data: https://open-research-data.zalf.de/SitePages/DatasetInformation.aspx?ord=DK_154 |
Value of the Data

- The data set provides a spatially explicit standardized set of relevant indicators to support the comprehension of the multifunctionality of the agricultural landscape in terms of ecosystem service supply and allowing to identify synergies and trade-offs among services.
- Different groups of stakeholders as well as scientists can use the dataset to support decision-making, land use planning and to tackle potential or actual conflicts in land use.
- Data can be used to identify hot and cold spots of ecosystem service provision and support the creation of suitability maps for specific land management in order to tailor decisions on land use change to the local conditions.

1. Data Description

The dataset contains six standardized (0-1) indicators of ecosystem services provision for the agricultural lands (140,116 ha) of the Märkisch-Oderland District in east Brandenburg, Germany, and is organized in an ESRI shape file that maps the indicators and provides thematic information on land cover and soil class. The six ecosystem services (Table 1) were chosen in reference to the Common International Classification of Ecosystem Services (CICES) [1] and are: i) biomass production (PRO), ii) water storage (WAS), iii) carbon stock total (CST), iv) carbon stock potential (CSP), v) habitat for species (HAB), and vi) landscape attractiveness (LAT). The data set has 140,116 entries, each one corresponding to a 1 ha size cell (100 m x 100 m), whose centroid coordinates are provided according to the EPSG:4839 - ETRS89/LCC Germany (N-E) - Projected coordinate system for Germany. Each indicator value is standardized as number in the range of 0 to 1. The maximum values observed in the study area are then set equal to 1, and the values 0 indicate the relative minima in the area considered. For each entry, the dataset provides information about landscape unit, dominant land cover, dominant soil and cadastral parcel. Table 2 provides a description of the fields of table data table associated to the shape file provided as supplementary data file.

2. Experimental Design, Materials and Methods

The assessment of the six indicators resorted to different methods depending on the availability of data to be used as proxies. To ensure comparability and immediate comprehension, all indicators are standardised within a 0-1 range resorting to an interval normalization transformation [2]:

\[ x_{i\ 0-1} = (x_i - x_{\min})/(x_{\max} - x_{\min}) \]  

(1)

where \( x_{i\ 0-1} \) is the standardized value [0-1], \( x_i \) is the current value, \( x_{\min} \) and \( x_{\max} \) are respectively the minimum and maximum of each variable considered. The maximum value observed in the study area is then set equal to 1, and the value 0 indicates the relative minimum in the area considered. The results depends then upon the degree of variability observed in the variable used to build the indicator, whose ranges are highly dependent on the scale of the raw data and are different for each variable. All GIS operations and mapping were performed using QGIS v3.8.3 [3]. A complete description is given for each indicator. At the adopted working scale is not possible to validate the results in strict sense. However, the indicators were chosen on the base of well-established schemes and developed at a spatial scale suitable with available data on one side and with the identification of planning strategies on the other.
| Description | Proxy for indicator | CICES Section | CICESDivision | CICESGroup | CICES Class | CICES Code | CICESClass type |
|-------------|---------------------|---------------|--------------|------------|-------------|------------|----------------|
| 1 Biomass Production (PRO) | NDVI on agricultural land for June (avg. 2000-2019) | Provisioning (biotic) | Biomass | Provisioning (biotic) | Biomass | Cultivated terrestrial plants for nutrition, materials or energy | 1.1.1 | Crops by amount, type (e.g. cereals, root crops, soft fruit, etc.) |
| 2 Water Storage (WAS) | Topographic Wetness SAGA Index | Regulation & Maintenance (Biotic) | Regulation of physical, chemical, biological conditions | Regulation of physical, chemical, biological conditions | Cultivated terrestrial plants for nutrition, materials or energy | 1.1.2 | Material by amount, type, use, media (land, soil, freshwater, marine) |
| 3, 4 Carbon Stock Total (CST) / Carbon Stock Potential (CSP) | C stock (0-30 cm) Mg ha⁻¹, Soil class, CORINE land cover class, elevation, NDVI (June-August 2000-2019) | Regulation & Maintenance (Biotic) | Transformation of biochemical or physical inputs to ecosystems | Mediation of wastes or toxic substances of anthropogenic origin by living processes | Cultivated plants (including fungi, algae) grown as a source of energy | 1.1.3 | By amount, type, source |
| 5 Habitat for Species (HAB) | Sum of the area share under Natura2000, FFH, NSG | Regulation & Maintenance (Biotic) | Regulation of physical, chemical, biological conditions | Atmospheric composition and conditions | Hydrological cycle and water flow regulation (Including flood control) | 2.2.13 | By depth/volumes Hydrological cycle |
| 6 Landscape Attractiveness (LAT) | Density of green linear elements and green point elements, Occurrence of grasslands, field size | Cultural (Biotic) | Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting | Intellectual and representative interactions with natural environment | Characteristics of living systems that enable aesthetic experiences | 3.1.2.4 | By type of living system or environmental setting |
**Table 2**
Content of the data set.

| Column name     | Description                                                                                                                                 |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| id              | Cell (1 ha) identifier                                                                                                                     |
| xcoord          | Spatial coordinate, coordinate reference system ETRS89/LCC Germany (N-E) EPSG: 4839                                                        |
| ycoord          | Spatial coordinate, coordinate reference system ETRS89/LCC Germany (N-E) EPSG: 4839                                                        |
| NATRAUM_ID      | Landscape unit identifier (num)                                                                                                           |
| NATRAUM_BEZ     | Landscape unit name                                                                                                                        |
| CORINE Land Cover | CORINE Land cover class description                                                                                                       |
| CLC_code        | CORINE Land cover class code, 3rd level                                                                                                  |
| Boden Hauptgruppe | BÜK300 Soil great group (in German)                                                                                                       |
| Boden Gruppe    | BÜK300 Soil group (in German)                                                                                                             |
| BÜK 300_Boden_Kl | BÜK300 Soil class identifier (number)                                                                                                     |
| FBID            | DFBK20/BB Land parcel identifier from Digitales Feldblockkataster des Landes Brandenburg 2020 (alphanumeric)                           |
| PRO             | ES indicator: Biomass production (range: 0-1)                                                                                             |
| WAS             | ES indicator: Water storage (range: 0-1)                                                                                                  |
| CST             | ES indicator: C stock total (range: 0-1)                                                                                                  |
| CSP             | ES indicator: C stock potential (range: 0-1)                                                                                               |
| HAB             | ES indicator: Habitat provision (range: 0-1)                                                                                               |
| LAT             | ES indicator: Landscape attractiveness (range: 0-1)                                                                                         |
| missing_values  | Code for missing values99999 = no value                                                                                                    |

![Map of Märkisch-Oderland and Brandenburg with biomass production indicator](image)

**Fig. 1.** Märkisch-Oderland (MOL), Brandenburg (BB): indicator of biomass production (PRO).

### 2.1. Biomass production (PRO)

The indicator for biomass production is based on the value of the normalized difference vegetation index (NDVI) for the months of June, averaged over the years 2000-2019. Primary data are MODIS NDVI raster files (16 days average, 250 m resolution) which have been freely downloaded. Due to cloud cover, 16 raster images out of 40 were used for calculation and assessment. The resulting map for the biomass production indicator is shown in Fig. 1. The pattern observed on the map is coherent with agricultural intensity, land use and dominant soil characteristics.
2.2. Water storage (WAS)

The indicator is based on the SAGA Wetness Index [4], derived from the 20 m resolution ASTER Digital Terrain Model (DTM), freely downloaded from the following URL: https://lpdaacsvc.cr.usgs.gov/appeears/. Topography is the main factor controlling water flow and accumulation within a watershed, and the Topographic Wetness Index (TWI) using a DTM calculates for each pixel the capacity of water accumulation. The TWI leads to not fully reliable results in lowlands, as these are artificially subdivided into sub-catchments based on minor differences in the DTM. The SAGA Wetness Index is similar to the Topographic Wetness Index (TWI), but it is based on a modified calculation of the upslope contributing area for each pixel, which does not assume that the flow occurs as very thin film. Consequently, it returns a more representative, higher soil moisture potential for areas situated in valley bottoms with reduced vertical distance to the channel network compared to the standard TWI calculation. The calculation was done in Rstudio using the package RSAGA [5] and the resulting raster file was upscaled from 20 to 100 m resolution using a bilinear interpolation in R. The resulting map for the water storage indicator is shown in Fig. 2. The resulting spatial distribution of the indicator is strictly related not only to topography and landforms, but also to dominant soil texture.

2.3. Carbon stock total (CST)

The source data (Mg ha⁻¹, 0-30cm) were derived from the GSP-FAO soil carbon stock map (GSOCmap V1.5, http://54.229.242.119/GSOCmap/) with a resolution of 1km, and downscaled to 100 m resolution via a forward stepwise General Linear Model (GLM) regression followed by Regression Kriging. The GLM and the regression kriging were implemented in Rstudio [6], using the library automap [7]. Input to the regression model (R² 0.31) were soil class, CORINE land cover class, elevation (m) and normalized difference vegetation index (NDVI, -) for the months of June and August (average 2000-2019). The statistics of ANOVA for the GLM regression are presented in Table 3. In order to deal with the asymmetry of the distribution (skewness 4.26), the estimated values of C stock were log-transformed and then standardised to the range [0, 1]. The map of the CST indicator for the study area is presented in Fig. 3. The spatial distribution
Table 3  
ANOVA for the GLM regression for C stock downscaling.

| Response          | Df  | Sum Sq. | Mean Sq. | F value | Pr(>F)  |
|-------------------|-----|---------|----------|---------|---------|
| CLC class         | 20  | 907409  | 45370    | 72.18   | < 2.2e-16 *** |
| DEM               | 1   | 513578  | 513578   | 817.03  | < 2.2e-16 *** |
| NDVI june        | 1   | 227416  | 227416   | 361.78  | < 2.2e-16 *** |
| NUVI august      | 1   | 114404  | 114404   | 182.00  | < 2.2e-16 *** |
| Soil class       | 66  | 597355  | 9051     | 14.40   | < 2.2e-16 *** |
| Residuals        | 8128| 5109223 | 629      |         |          |

Fig. 3. Märkisch-Oderland (MOL), Brandenburg (BB): indicator of Carbon stock total (CST).

...of the indicator is ruled by the distribution of main soil types, i.e. alluvial soils, soils on glacial deposits and organic soils.

2.4. Carbon stock potential (CSP)

The SOC stock estimates are used to infer possible SOC stock changes in terms of carbon sequestration potential. The carbon sequestration potential (CSP) was assessed following the approach proposed by Stolbovoy et al. [8,9] modified as in Ungaro et al. [10]. The calculation of the indicator is based on the assumptions that: i) soil classes are different in SOC content; ii) SOC content results from the combination of soil class and land use; and iii) each soil class/land use combination has specific SOC ranges which limit potential SOC changes within specific range boundaries. The upper limit of the SOC specific range was the 95th percentile of the observed distributions of each soil class/land use combination (N=135) in order to cut out outliers and extreme values. The calculation of the potential C stock (Mg ha\(^{-1}\)) is then as follows:

\[
\text{Cstock potential}_{30} (\text{Mg/ha}) = p95_{\text{Cstock}_{30}} \text{bklci} - C\text{stock}_{30} \text{bklci (x,y)}
\]
where \( p_{95, \text{Cstock}_{30 \text{ bkcl}c}} \) is the 95th percentile of the C stock distribution for each \( i \)th soil class and land cover class combination, and \( \text{Cstock}_{30 \text{ bkcl}c}(x,y) \) is the value of the C stock (Mg ha\(^{-1}\)) estimated at the centroid of any given raster cell centroid of coordinates \((x,y)\) with the same \( i \)th soil class and land cover class combination. The value of CSP was set to 0 for organic soils and for soil with SOC > 100 Mg ha\(^{-1}\) (0-30 cm) as these act as source of C, for a total of 11,376 ha, 8.1\% of the agricultural land area. In this case too, in order to deal with the asymmetry of the distribution (skewness 6.67), the estimated values of C stock were log-transformed and then standardised to the range [0, 1]. The map of the CSP indicator for the study area is presented in Fig. 4. The pattern observed on the map is coherent with the distribution of major soil types and dominant land use.

2.4. Habitat for species (HAB)

The indicator of habitat provision is based on the sum of the area share under specific designations, i.e. Natura2000 (Nat2000), Flora and Fauna Habitat (FFH), and Protected areas (NSG), for each cadastral parcel of the utilised agricultural land, as provided by the Ministry for Rural Development, Environment and Agriculture of the State of Brandenburg (MLUL). The resulting map in Fig. 5 shows for the agricultural lands the values of the indicator in the Märkisch-Oderland District-Brandenburg (Germany).

2.5. Landscape attractiveness (LAT)

This indicator is based on the (co-)occurrence, in the agricultural areas of the district, of four landscape attributes with different levels, i.e. green linear elements (e.g. hedgerows, tree lines), green point elements (e.g. woodlots, isolated trees), grasslands (as a proxy of grazing livestock) and field size (as a proxy of crop diversity). The approach for its estimation resorts to the preference study results by Häfner et al. [11] and follows the methodology used to map cultural ecosystem services given by Ungaro et al. [12], whose quality was validated through a number of stakeholders’ workshops. As for linear and point elements, the approach encompassed the following steps [13]: (i) stratified random sampling of landscape elements within a regular reference grid (1 km \( \times \) 1 km) to assess the presence or absence of specific landscape features with
a 250 buffers around two randomly selected points within each grid cell (N = 4,676; sampling density 2.1 km\(^{-2}\)); (ii) creation of an indicator data set (0 = absence, 1 = presence) followed by experimental variography and indicator variogram modelling; (iii) sequential indicator simulations [14], using variogram models over a 100 m regular grid (N = 140,116 for the whole study area); and (iv) post-processing of simulations results (N = 1,000) to compute for each grid cell the E-type estimator [15], i.e. the mean probability of occurrence of the considered landscape elements. The following table reports the level and the score for each level of the four attributes considered to assess the attractiveness of the agricultural landscape. The sum of the scores for each grid cell was eventually normalised to provide the map of the indicator depicted in Fig. 6. Table 4.
Table 4
Attractiveness scores for landscape attributes.

| Attribute     | Level | Criteria   | Score |
|---------------|-------|------------|-------|
| Linear elements | 1     | Occurrence <0.33 | 0.00  |
|               | 2     | Occurrence 0.33-0.66 | 1.18  |
|               | 3     | Occurrence >0.66  | 2.10  |
| Point elements | 1     | Occurrence <0.33 | 0.00  |
|               | 2     | Occurrence 0.33-0.66 | 0.22  |
|               | 3     | Occurrence >0.66  | 1.38  |
| Grassland     | 0     | Absence       | 0.00  |
|               | 1     | Presence       | 0.75  |
| Field size    | 1     | >15 ha        | 0.00  |
|               | 2     | 5-15 ha       | 0.13  |
|               | 3     | <5 ha         | 1.03  |

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jib2020.106645.

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