

ESTIMATING LAND USE/LAND COVER AND CHANGES IN DENMARK

Technical documentation for the assessment of annual
land use/land cover and changes since 2011

Technical Report from DCE – Danish Centre for Environment and Energy

No. 227

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Data sheet

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Abstract:	Due to Denmark's ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, Denmark is obliged to document sequestration and emission of carbon dioxide from land use and land cover and changes in these. According to the IPCC guidelines, estimation of land use and land cover must cover following land use and land cover categories: Settlement, Cropland, Grassland, Wetland, which is fully water covered, Wetland, which is partly water covered, Forestland and Other land. Since the first assessment for the period from 1990 to 2012 (Levin et al., 2014), several methodological adjustments have been compiled. This report documents and describes applied data and developed for estimating annual amounts and changes in land use and land cover for Denmark for the period from 2011 to 2020.
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Preface

This report describes applied data and methods for the estimation of land use and land cover in Denmark for the period from 2011 to 2020. Applied data and methods have been compiled and developed by the Danish Centre for Environment and Energy at Aarhus University (DCE). Estimated area and change in land use and land cover form the input to Denmark's obligations to document fixation and emission of carbon dioxide from land use and land cover for its reporting to UNFCCC and under article 3.4 of the Kyoto Protocol.

Sammenfatning

Som følge af Danmarks ratificering af FNs Klimakonvention (UNFCCC, United Nations Framework Convention on Climate Change) og Danmarks ratificering af Kyotoprotokollen, er Danmark forpligtet til at dokumentere binding og udslip af kuldioxid fra arealanvendelse og arealdække samt fra arealændringer. Til dette formål blev der, for Danmark, udviklet metoder til at estimere omfang og ændringer i arealanvendelse og arealdække siden 1990. I henhold til IPCC's retningslinjer, skal estimeringen af omfang og ændringer i arealanvendelse og arealdække omfatte følgende arealkategorier: Bebyggelse, dyrkede arealer, græsarealer, vådområder, som er dækket af vand hele året, vådområder, som i perioder er dækket af vand, skov og andre arealer. Siden den første opgørelse for perioden fra 1990 til 2012 (Levin m.fl., 2014) er der blevet gennemført en række tilpasninger af metoden for at opgøre årlige ændringer i arealanvendelse og arealdække fra 2011 frem til 2020. Nærværende rapport beskriver anvendte data samt metoden.

Siden 2011, er årlige estimeringer af arealanvendelse og arealdække samt ændringer i disse baseret på eksisterende kategorisk (præ-klassificeret) geografisk information. Denne information omfatter topografiske kort, landbrugsregistre og markkort, data fra natur og habitatmonitoring, samt kortlag over etablering af vådområder. Efter forbehandling, som fx fjernelse af geometriske fejl, konverteres alle inputdata til rasterlag med en celledørrelse på 25x25 meter. Rasterlagene kombineres i et samlet kort over arealanvendelse og arealdække for det givne år. Fordi inputdata ofte overlapper, er kombinationen til et samlet kort baseret på en vurdering af den tematiske og geometriske præcision af hvert lag. Endelig præsenteres og diskuteres estimerede arealændringer for hele perioden fra 1990 til 2020.

Summary

Due to Denmark's ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, Denmark is obliged to document sequestration and emission of carbon dioxide from land use and land cover and changes in these. For this purpose, methods were developed aiming at estimating amounts and changes in land use and land cover for Denmark since 1990. According to the IPCC guidelines, estimation of land use and land cover must cover following land use and land cover categories: Settlement, cropland, grassland, wetland, which is fully water covered, wetland, which is partly water covered, forestland and other land. Since the first assessment for the period from 1990 to 2012 (Levin et al., 2014), several methodological adjustments have been compiled to estimate annual land use and land cover and annual changes in these for the period from 2011 to 2020. The present report describes applied data and methods.

Since 2011, annual estimations of land use and land cover categories and changes in these are based on existing categorical (i.e. pre-classified) geographical information. This information includes topographical maps, agricultural registers and field parcel maps, data from nature and habitat monitoring and maps of wetland restoration. After pre-processing, such as removal of geometrical errors, all input data are converted into raster layers with a cell size of 25x25 meters and combined into one land use/land cover map for the specific year. Since input data often spatially overlap, their combination into one map is based on an evaluation of the thematic and geometric precision of each layer. Finally, for the whole period from 1990 to 2020, estimations of changes in land use and land cover are presented and discussed.

1 Introduction

This report describes the applied data and methodology for the estimation of land use/land cover (LULC) and changes in Denmark for the period from 2011 to 2020. Estimated LULC changes were subsequently applied to assess sources and sinks for climate gasses and were reported in Nielsen et al. (2021). The estimation of LULC and LULC changes was based on mapping of the extent and change between seven LULC categories, as defined by the IPCC guidelines (Penman et al., 2003). These LULC categories are: settlement, cropland, grassland, forestland, wetlands – fully water covered, wetlands – partly water covered, and other land. The mapping was based on available categorical (i.e. pre-classified) geo-graphical information

The report is structured as follows: Chapter 2 explains the overall methodological approach. Chapter 3 presents the applied input datasets. Chapter 4 describes applied methods for the delineation of the seven LULC categories. Chapter 5 describes the applied method for assessment of changes between LULC categories. Finally, Chapter 6 presents and discusses overall LULC changes for the period from 1990 to 2020 and spatially explicit changes from 2011 to 2020.

The following nomenclature is followed throughout this report:

- Object type: An object type is here defined as a distinct land use or land cover type. Examples are “building”, “city centre” or “forest”. Each object type has an object code in the dataset from which it originates. The object code can be a number or a text string.
- Input dataset: Datasets or data sources applied in the analysis. One dataset can include several object types. Examples are the national topographic database, the field parcel map and the wetland restoration designations.
- Input layer: Input layers are here defined as the generated maps representing the seven LULC categories and if information exists, changes in these from 1990 to 2011. Examples are settlement, forestland etc.

The applied geographical projection for all applied input datasets is UTM ETRS1989 zone 32 N.

2 Overall methodology

Figure 2.1 illustrates the overall method to assess LULC and annual changes in LULC exemplified for 2020 and the period from 2019 to 2020. From the applied input datasets, specific object types are extracted and combined to create individual input layers for the seven LULC categories. These input layers are overlaid with and spatially adjusted to the LULC layer from the previous year (in this case 2019) resulting in a LULC layer for 2020. Finally, overlaying the LULC layers from 2019 and 2020, LULC-changes are mapped for this period.

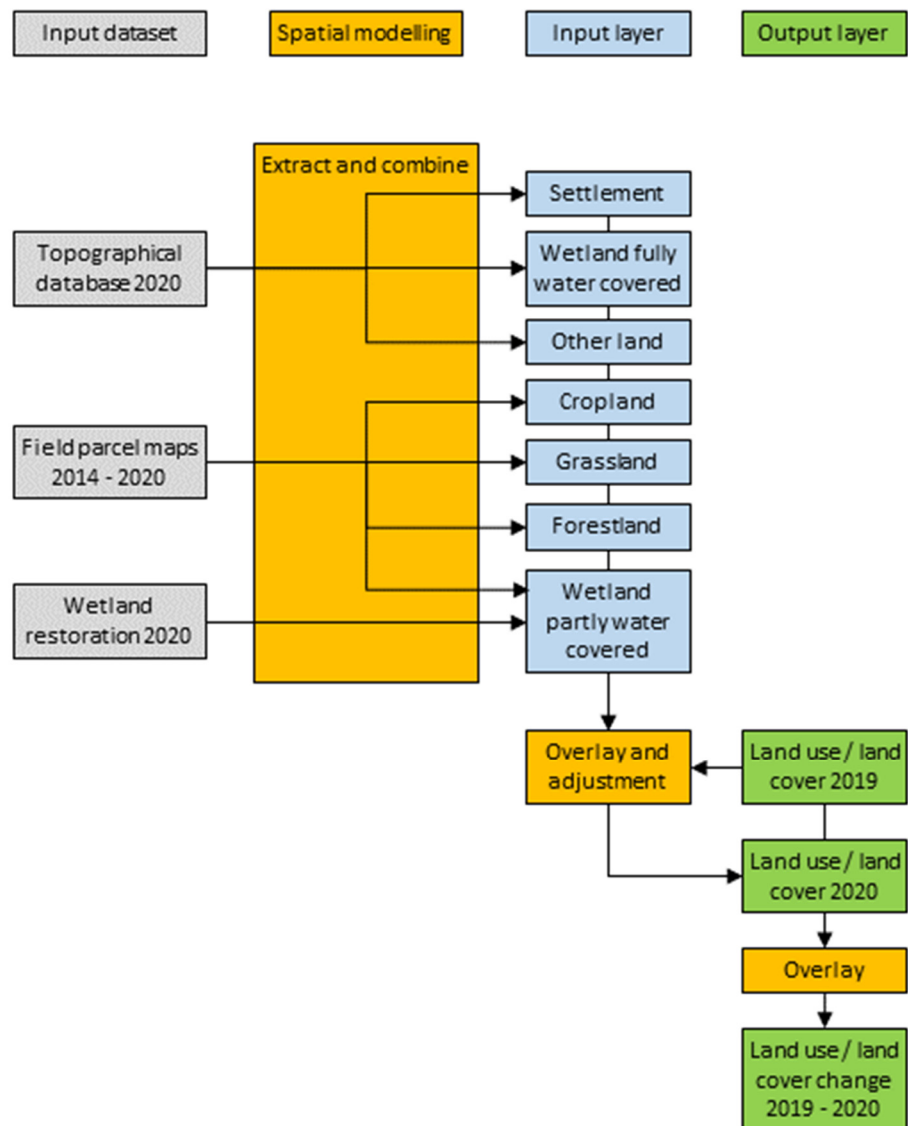


Figure 2.1 Illustration of applied overall methodology for assessment of annual land use/land cover for 2020 and changes from 2019 to 2020.

3 Input datasets

3.1 Topographical database

The Danish topographical database provides basic topographical data. Until 2017, the database was named Kort10. Since 2017, it is named GeoDanmark. For this report, topographical data are referred to as the *topographical database*. The method used to identify and categorise object types is a combination of in situ observation and air-photo interpretation. The topographical database is kept up to date by the Agency for Data Supply and Efficiency (SDFE) together with Danish municipalities. Although data are updated continuously, present datasets contain information, which is up to four years old. The topographical database contains a total of 54 object types. For this study, 14 object types were applied to map three of the seven input layers: settlement, wetlands – fully water covered, and other land. The current version of the Danish topographical database can be downloaded from the homepage of the Agency for Data Supply and Efficiency (SDFE). For the current project, topographical data were downloaded for each year for the period from 2012 to 2020 (SDFE, 2012 – 2020).

3.2 Agricultural data

3.2.1 Field parcel maps

Since 2010, agricultural land use data are available as field parcel maps. The field parcel maps contains objects and information on land use type for every field parcel, managed by a person or enterprise, applying for agricultural subsidies. Field parcel maps for the period from 2010 to 2020 contain approx. 600,000 individual field parcels and 357 object types. For this study, field parcel maps for the period from 2010 to 2020 (Danish Agricultural Agency 2010-2020) were applied to map four of the seven input layers: cropland, grassland, wetland – partly water covered, and forestland.

3.2.2 Field block maps and agricultural registers

Until 2010, agricultural land use data are only available at the scale of field blocks. The field block map demarcates the area, within which persons or enterprises can apply for agricultural subsidies. The Danish field block map contains about 300,000 field blocks. One field block may contain up to ten individual field parcels. Agricultural registers contains land use information for each field parcel, for which a person or enterprise has applied for agricultural subsidies and a unique spatial reference to the field block within which the parcel is located. Since Grassland is only mapped in areas which have been registered as Grassland for at least five consecutive years (section 4.3.1) in order to map Grassland for the years 2012 and 2013, field block maps and agricultural registers for the years 2008 and 2009 were applied (Danish Agricultural Agency 2008-2009a; Danish Agricultural Agency 2008-2009b).

3.3 Wetland restoration designations

Starting with the second action plan for the aquatic environment (Vandmiljøplan 2), which was approved in 1998, areas for wetland restoration have continuously been designated. These designations are available as vector layers comprising different kind of measures, such as areas for reduction of leaching of nitrogen and phosphor, restoration of natural hydrology and wetland restoration in low-lying areas (lavbundsområder). These vector layers, which were provided by the Danish Agricultural Agency (Danish Agricultural Agency, 2011 - 2021) include 653 designations and a total of around 31,000 hectares and were applied to map wetland – partly water covered.

4 Delineation of LULC categories

4.1 Conversion to raster format

The applied geographical projection for all applied input datasets is UTM ETRS1989 zone 32 N. The applied input datasets are in vector format, while the generated LULC maps are in raster format with a cell size of 25x25 meters. Therefore, in the first modelling step, all input datasets were converted to raster format as illustrated in Figure 4.1.



Figure 4.1 Conversion from vector format to raster format illustrated for an extract of the field parcel map.

4.2 Settlements

Settlement is defined as developed land including transportation infrastructure and human settlements. The settlement layer is based on 12 object types derived from the topographical database (Table 4.1).

Table 4.1 Applied object types for settlement.

Object name (Danish)	Object name (English)	Original object code	Data source
Startbane	Runway	9970	Topographical database (SDFE 2012-2020)
Teknisk areal (ekskl. vindmølleparker)	Technical area (excl. wind farms)	9901	Topographical database (SDFE 2012-2020)
Bassin	Basin	9902	Topographical database (SDFE 2012-2020)
Bykerne	City centre	9952	Topographical database (SDFE 2012-2020)
Erhverv	Business	9953	Topographical database (SDFE 2012-2020)
Lav bebyggelse	Low built up	9954	Topographical database (SDFE 2012-2020)
Høj bebyggelse	High built up	9955	Topographical database (SDFE 2012-2020)
Rekreativt område	Recreational area	9974	Topographical database (SDFE 2012-2020)
Bygning	Building	9946	Topographical database (SDFE 2012-2020)
Begravelsesområde	Graveyard	9978	Topographical database (SDFE 2012-2020)
Vejmidte brudt (trafikvej; lokalvej primær; overjordisk)	Road centreline (traffic road; local primary road; above ground)	9963	Topographical database (SDFE 2012-2020)
Jernbane (overjordisk)	Railway (above ground)	9964	Topographical database (SDFE 2012-2020)

4.3 Cropland and grassland

According to the IPCC guidelines (Penman et al., 2003), cropland includes arable and tillage land, and agro-forestry systems, where vegetation falls below the thresholds used for the forestland category, consistent with the selection of national definitions. For the Danish inventory, cropland is defined as land intensively utilized for agricultural purposes.

According to the IPCC guidelines, grassland includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forestland category and are not expected to exceed, without human intervention, the threshold used in the forestland category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvopastoral systems, subdivided into managed and unmanaged consistent with national definitions. For the Danish inventory, grassland is defined as land with grass and herb vegetation, which is used for grazing and other areas where the vegetation is maintained at a state, which implies that it does not hold trees with a crown cover of at least 10 percent. In this case, it would meet the definition for forestland. Grassland includes, among other, extensively managed grassland, dry grassland and heathland.

For the annual update of LULC grassland and cropland, layers are derived from the field parcel maps. The aggregation of the 357 land use categories in the applied field parcel and agricultural registers into grassland and cropland is presented in the appendix.

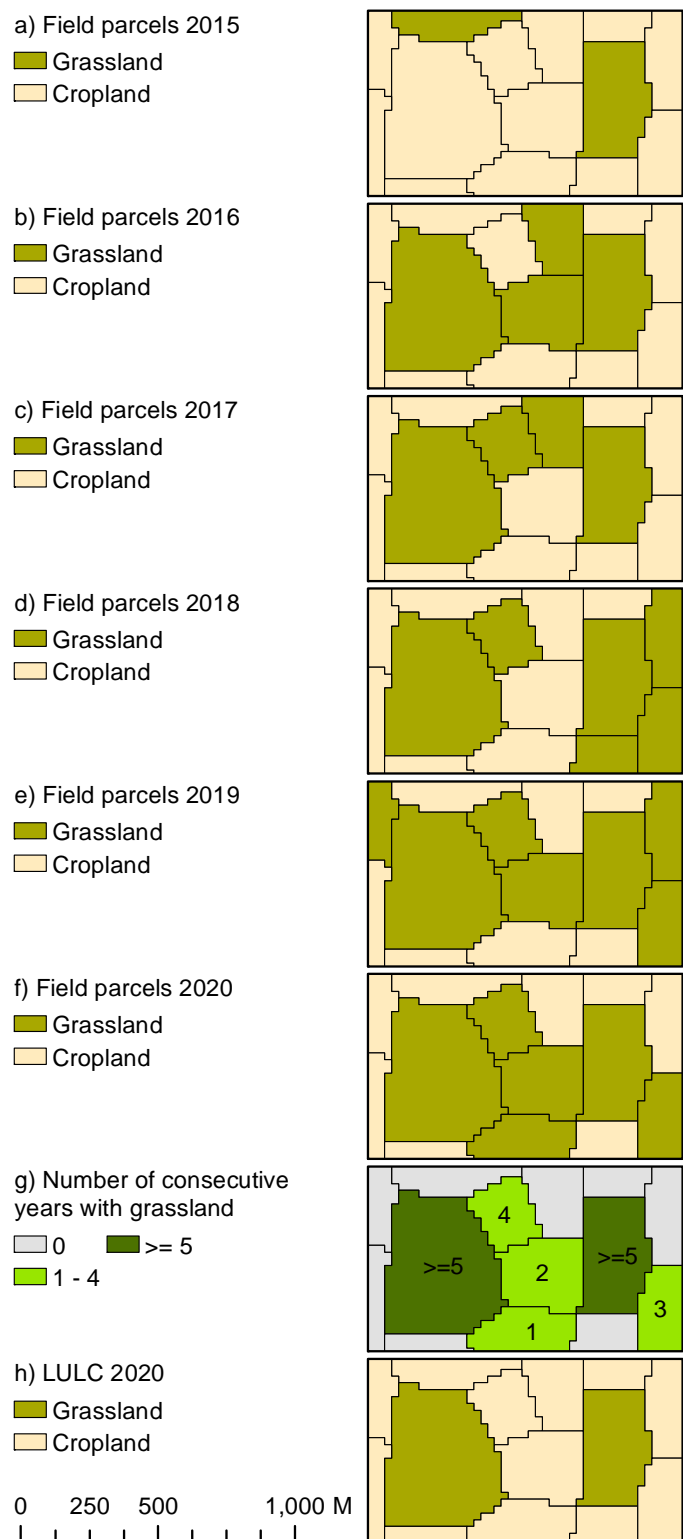
Furthermore, for the Danish inventory, grassland is only mapped for areas, which have been grassland for at least five consecutive years. The applied methodology is described in the next paragraph.

4.3.1 Mapping dynamics between cropland and grassland

A direct overlay of field parcel maps results in considerable fluctuations in the cropland and grassland area as well as in a sizeable area where cropland changes to grassland in one year, but returns to cropland within the next four years. Such considerable dynamics between cropland and grassland, where a considerable area is mapped as grassland for less than five consecutive years poses a challenge to the emission inventory, where areas, which undergo a change are reported as “converted to” for the next 20 years. I.e. areas with complex dynamics, such as “from cropland to grassland to cropland” will, in the inventory count several times and the total area of “converted to” thus becomes very large.

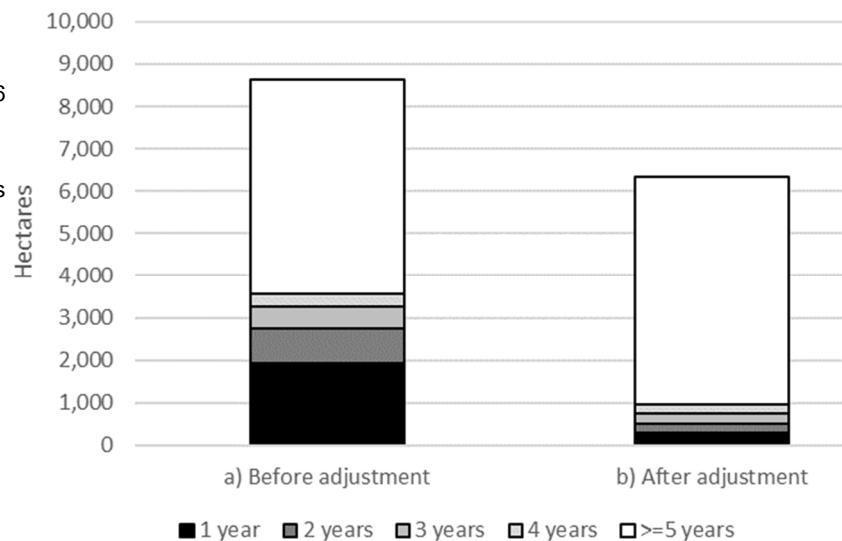
In order to reduce the influence of complex dynamics between cropland and grassland, for the Danish inventory it was decided only to map changes from cropland to grassland for areas, which in the applied field parcel maps were registered as grassland for at least five consecutive years. The period of five years was chosen as it is in line with the Danish regulation of agricultural subsidies (Danish Agricultural Agency 2020). The applied methodology is illustrated in Figure 4.2.

Figure 4.2 Illustration of applied method for mapping grassland and cropland for 2020 accounting for annual changes between grassland and cropland. Field parcel maps for the years 2015 to 2020 (a-f) are overlaid and the number of consecutive years each parcel was registered as grassland is calculated (g). For the final LULC map for 2020, only parcels, which were registered for at least 5 consecutive years are mapped as grassland (h).



For the year 2016, Figure 4.3 illustrates the consequence of only mapping grassland converted from cropland in areas which in the field parcel maps were registered as grassland for at least five consecutive years (after adjustment) compared to mapping any grassland converted from cropland (before adjustment). Before adjustment, more than 40 percent of the area, which from 2015 to 2016 was mapped as a change from cropland to grassland had by 2020 returned to grassland. After adjustment, this proportion is reduced to approx. 15 percent.

Figure 4.3 Persistence of area mapped as converted from cropland to grassland between 2015 and 2016 before (a) and after adjustment (b). Number of years refers to the number of years, before the area has returned to cropland.



4.3.2 Allocating Cropland and Grassland before 2010

Until 2010, information about agricultural land use was only available for field blocks. Since the mapping of Grassland and Cropland for the years 2012 and 2013 requires information about the location of these classes five years back, that is, back to the year 2008, information at field block level was applied for the years 2008 and 2009. Because field block maps only contain the area of different crop types within each field block but not the precise location, the location of Grassland and Cropland for the years 2008 and 2009 was determined as follows: First, for each field block, the area of Grassland and Cropland was summarised. If a field block only contains either Grassland categories or Cropland categories, the whole field block is mapped as Grassland or Cropland. For the 2009 field block map, this is the case for around 94 % of the blocks. Second, the remaining field blocks were overlaid with the Grassland/Cropland map of the subsequent year (for 2009 derived from the 2010 field parcel map). For each field block the area of Grassland and Cropland for the subsequent year was summarised. For blocks, where both the ratio between Grassland from the agricultural register and Grassland from the subsequent year and the ratio between Cropland from the agricultural register and Cropland from the subsequent year was ≥ 0.9 and ≤ 1.1 it was assumed that the location Cropland and Grassland was the same as in the subsequent year. For 2009, this was the case for 3 % of the field blocks. Finally, for the remaining field blocks (for 2009 around 12,000 field blocks or 4 % of the blocks), Grassland and Cropland was allocated within the field block as described in Figure 4.4. This method was then repeated for the year 2008.

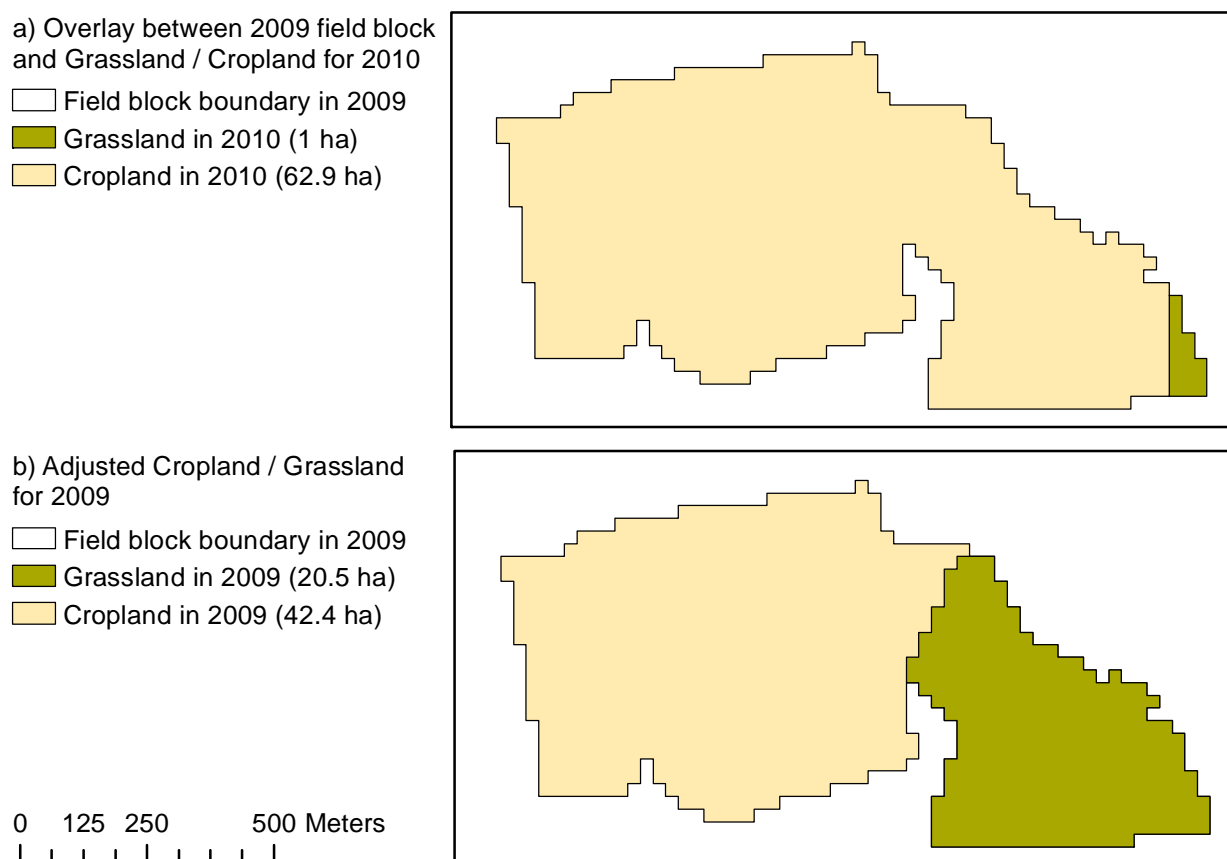


Figure 4.4 Allocating Grassland / Cropland within a field block. Illustrated for one field block from 2009. The Grassland area contained in the agricultural register from 2009 is 20.5 ha while the area Grassland area in 2010 was 1.0 ha (a). The difference (19.5 ha) was allocated by extending the Grassland area from 2010 into the Cropland area, until the mapped Grassland area equals the area from the agricultural register (b). For field blocks where the Cropland area in the agricultural register is smaller than the Cropland area in 2010, the Cropland area was extended into the Grassland area.



4.4 Wetland – fully water covered

Fully water covered wetlands are defined as lakes and other permanent water bodies which are saturated by water throughout the year. For the Danish inventory, areas of open sea are not included in this category. Fully water covered wetlands are represented object type *lake* (Danish name: *sø*; original object code: 9942) from the topographical database (SDFE 2012-2020).

4.5 Wetland – partly water covered



Partly water covered wetlands are defined as land that is covered or saturated by water part of the year. Partly water covered wetlands are derived from the land use categories *wetland for set-aside* (Danish name: *vådområde med udtagning*) and *Mini wetlands, approved* (Danish name: *Minivådområde, projekttilsagn*) from field parcel maps (Danish Agricultural Agency 2010-2020) as well as from maps of wetland restauration designations (Danish Agricultural Agency, 2011 - 2021). Designations of wetland restauration are rather imprecise and often include considerable agricultural categories, which do not comply with the definition of partly water-covered wetlands. Therefore, only areas of wetland restauration designations, which do not overlap with land use categories in the field parcel map of the respective year, which, by definition, exclude wetland, are mapped as new wetland. For all land use categories from the applied field parcel maps, the appendix includes information on whether the category excludes wetland or not. For a map section, Figure 4.5 illustrates the applied methodology.

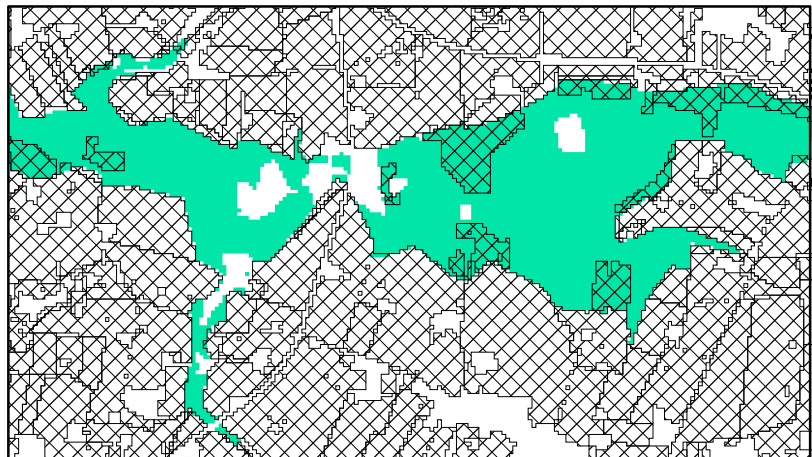
a) Overlay between wetlands in 2019 and wetland designations from 2020

-  Designation of wetland restauration 2020
-  Wetland 2019

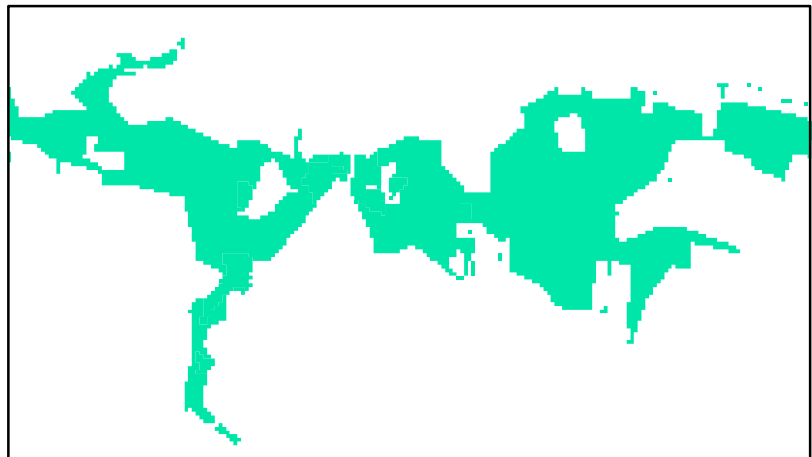


b) Overlay with 2020 field parcel map

-  Crop types excluding wetland
-  Designation of wetland restauration 2020



c) Adjustment wetland map 2020



0 0.5 1 2 Km




Figure 4.5 Illustration of applied method for mapping of Wetland, partly water covered for the year 2020. Wetlands from the LULC map for 2019 are overlaid with designations of wetland restauration for 2020 (a). New wetland areas for 2020 are overlaid with the 2020 field parcel map and areas with crop types, which exclude wetland, are identified (b). The adjusted wetland map for 2020 contains wetlands from 2019 and new wetlands, which do not overlap with crop types excluding the wetland category (c).

4.6 Forestland

Forestland is defined as woody vegetation having a minimum tree crown cover of 10 %, a minimum area of 0.5 ha, a minimum width of 20 meter and a minimum value for tree height, which must be able to reach a minimum height of 5 m at the site. In addition, the forest area includes temporarily unstocked areas, smaller open areas in the forest needed for management pur-

poses and fire breaks. Forests in national parks, reserves, or areas under special protection are included. Conifers for production of Christmas trees as well as forest for energy production, except willow plantations, are also reported under forest. Woody vegetation not meeting the forest definition, like shelter belts and fruit plantations for commercial purposes, orchards, gardens etc., which might be able to reach the forest definition, are reported under the Cropland category. Woody vegetation inside the area classified as Settlement which meet the forest definition is not included in forestland definition but reported under Settlement.

For the annual estimation of LULC changes after 2011, forestland is derived from the field parcel maps (Danish Agricultural Agency 2010-2020). The aggregation of the land use categories from the field parcel maps into Forestland is presented in the appendix.

4.6.1 Mapping afforestation and deforestation

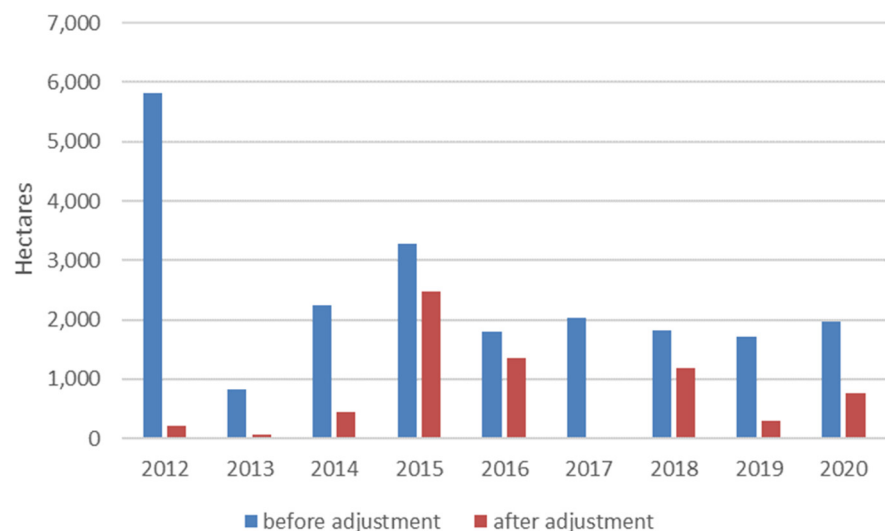
Change from other LULC categories to forestland, i.e. afforestation, is only mapped for areas, which are forest for at least two subsequent years. E.g. for the year 2016, an area is mapped as afforestation if it in the field parcel was registered as forestland in both 2014 and 2015. This rule is added in order to minimise biases from discontinued applications for subsidies for afforestation, which otherwise would lead to a considerable area, which in one year is mapped as afforestation and the following year as deforestation.

Furthermore, in principle cropland and grassland precludes forestland since agricultural subsidies necessitate removal of shrub and tree vegetation. Consequently, a change from forestland to cropland or grassland is mapped as deforestation. However, for 14 land use categories from the field parcel map, removal of shrub and woody vegetation is not compulsory (Table 4.2). Change from forestland to one of these categories is therefore not mapped as deforestation but as unchanged forestland. As shown in Figure 4.6, applying this rule, mapped annual deforestation decreases substantially.

Table 4.2 Land use categories from field parcel maps, where Forestland can appear. Source: Danish Agricultural Agency 2011-2020).

Name (Danish)	Name (English)	Original object code
Permanent græs, meget lavt udbytte	Permanent grass, very low yield	250
Permanent græs, lavt udbytte	Permanent grass, low yield	251
Permanent græs, normalt udbytte	Permanent grass, normal yield	252
Miljøgræs MVJ-tilsagn (0 N), permanent	Environmental grass (No nitrogen fertilization)	254
Rekreative formål	Areas for recreation purposes	271
Permanent græs og kløvergræs uden norm, under 50 % kløver	Permanent grass/clover grass without N-norm, <50% clover	276
Permanent græs og kløvergræs uden norm, over 50 % kløver	Permanent grass and clover grass without N-norm, >50 % clover	286
20-årig udtagning	20 years set-aside	312
Udtagning med fastholdelse, ej landbrugsareal	Wetland or low-lying areas with set-aside, not agricultural land	316
MVJ ej udtagning, ej landbrugsareal	Agri-environmental scheme, no set-aside, not agricultural land	318
MFO-brak, Udtagning, ej landbrugsareal	Agri-environmental scheme, set-aside, not agricultural land	319
Miljøtiltag, ej landbrugsarealer	Environmental initiative, not agricultural land	321
Naturarealer, økologisk jordbrug	Nature area, organic agriculture	907
Naturarealer, ansøgning om miljøtilsagn	Nature area, application for environmental subsidies	908

Figure 4.6 Mapped annual deforestation before and after accepting forestland on land use categories from field parcel maps, where Forestland can appear.



4.7 Other land

Other land comprises all LULC, which is not included in the other six LULC categories. It is defined as beaches, sand dunes and rock and has none or very limited carbon stock, both as living or dead biomass or as carbon in the soil.

Other land is generally characterised by few changes from or to other LULC categories and the quality of available input data for Other land does not allow for a reasonable assessments of LULC changes. Therefore, for Other land no changes are mapped and for all years the extent of this class from the LULC map for 2011 is applied.

5 Mapping annual LULC changes

5.1 Combination of input layers

In principle, all input layers are overlaid. For locations, where more than one input layer contains LULC information, LULC categories are prioritised following the hierarchy in Table 5.1, where categories with a high priority exclude categories with a lower priority. E.g. an area, which in the input layers from the topographic database is categorised as wetland, fully water covered and in the field parcel maps as cropland or grassland will be mapped as wetland, fully water covered. The overlay of the LULC categories is also illustrated in Figure 5.1.

Table 5.1 Hierarchy applied to prioritise LULC categories.

Hierarchy	LULC category
1	Sea
2	Other land
3	Settlement – transportation infrastructure
4	Wetland, fully water covered
5	Wetland, partly water covered
6	Cropland / grassland
7	Forestland
8	Settlement - built / sealed

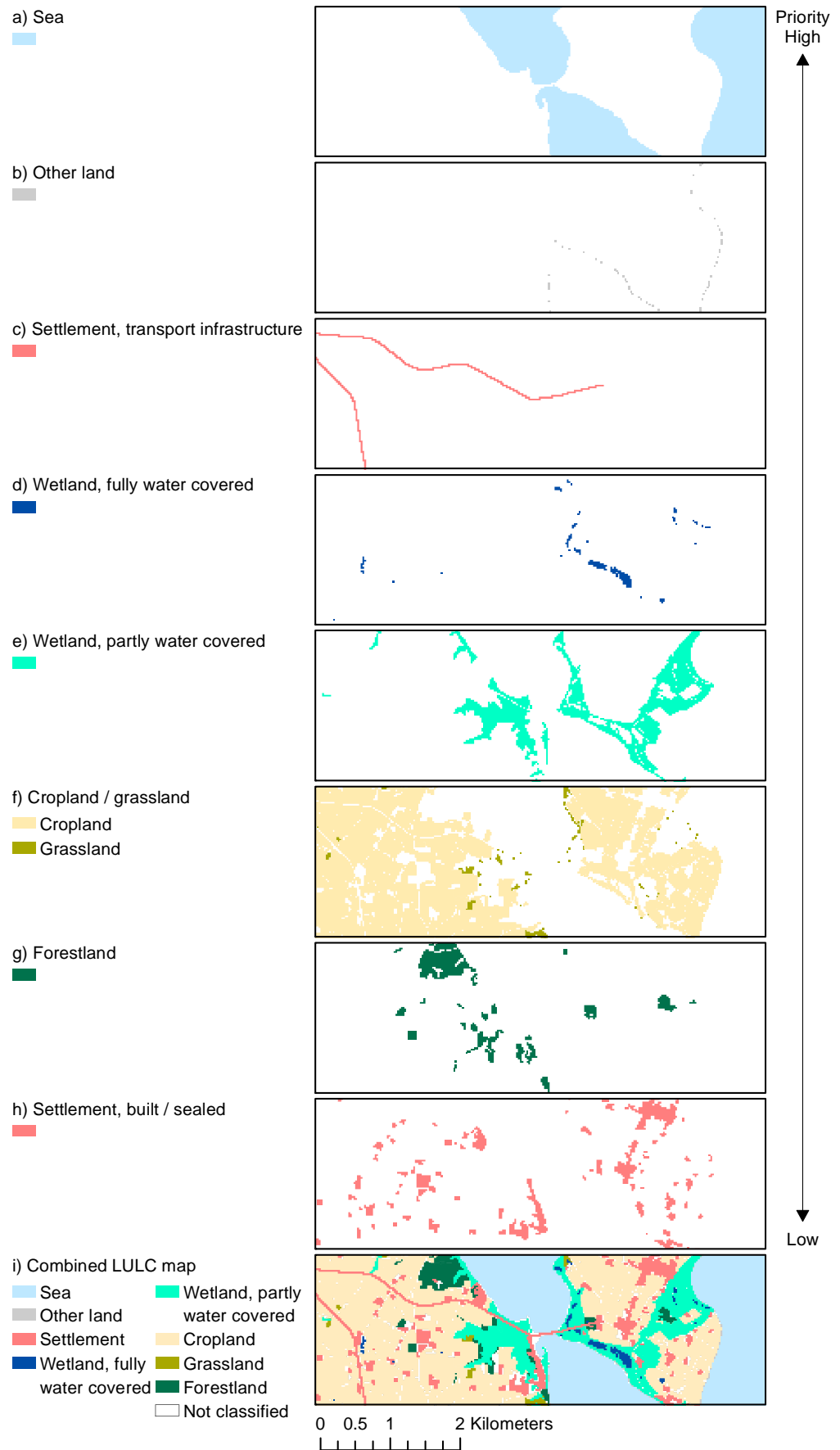


Figure 5.1 Illustration of combination of LULC categories for the year 2020. Categories (a-h) are overlaid. In the combined LULC map (i) categories with a high priority exclude categories with a lower priority.

5.2 Overlay with preceding LULC map

In order to map changes between LULC categories, the combined LULC map is overlaid with the LULC map of the preceding year. For the mapping of annual changes, following pre-assumptions are made:

- The total terrestrial area does not change. I.e. the coastline is kept constant for the whole assessment period and no changes from sea to other LULC categories (land reclamation) or from other LULC categories to sea are mapped.
- LULC categories cannot change to no LULC. I.e. in cases, where an area is mapped as a LULC category in one year, but is not contained in any of the applied input datasets in the subsequent year, except from terrestrial land, the LULC category is transferred to the subsequent year.
- Settlement is not removed. Although in few cases built or sealed areas and transport infrastructure is being transformed to other LULC-categories, for this assessment Settlement is considered a stable LULC category and no change from settlement to other LULC categories is mapped.
- Other land does not change. I.e. the extent of Other land is kept constant and no changes from other LULC categories to Other land or from Other land to other LULC categories are mapped.

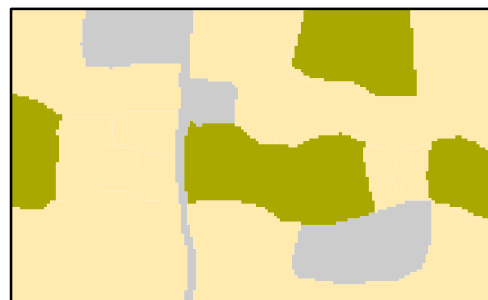
5.3 Removal of narrow areas of LULC change

The direct overlay of the combined LULC map with the LULC map of the preceding year results in a large amount of LULC changes, which are the consequence of small divergences between the delineation of the applied input layers for the different years, rather than actual changes in LULC. In order to reduce the impact of these divergences, areas with LULC change between two years, which have a width of equal to or less than two cells (50 meters) are not mapped. I.e. within these for these areas, LULC is kept in the same category as for the preceding year. This rule is applied to all LULC changes except from changes to transport infrastructure as roads and railways often have a width of less than 50 meters. For a map section, Figure 5.2 illustrates the applied methodology for change from cropland to grassland from 2019 to 2020. Figure 5.3 illustrates the applied methodology for a larger map section.

Figure 5.2 Applied methodology for removal of narrow areas of LULC change illustrated for change from cropland to grassland from 2019 to 2020. The LULC map for 2019 (a) is overlaid with the LULC map for 2020 (b). Areas with change from cropland to grassland are divided into areas with a width ≤ 50 meters and areas with a width > 50 meters (c). In the adjusted LULC map for 2020 (d) changes with a width > 50 meters are mapped as grassland while areas with a width ≤ 50 meters are mapped as cropland.

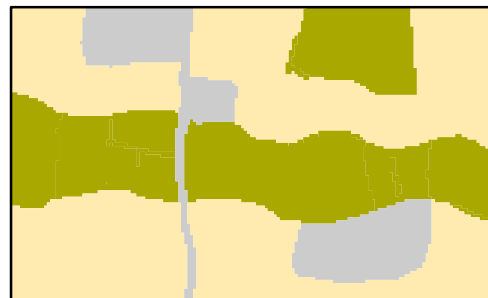
a) LULC 2019

- Cropland
- Grassland
- Other



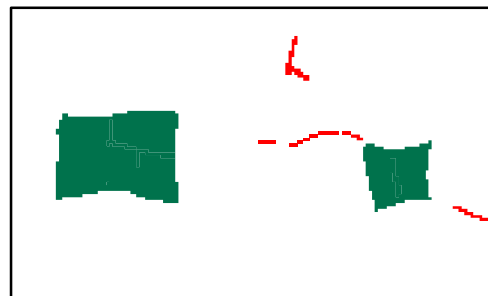
b) LULC 2020

- Cropland
- Grassland
- Other



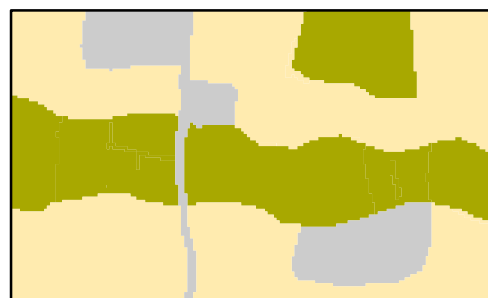
c) Change from cropland to grassland

- Width ≤ 50 meters
- Width > 50 meters



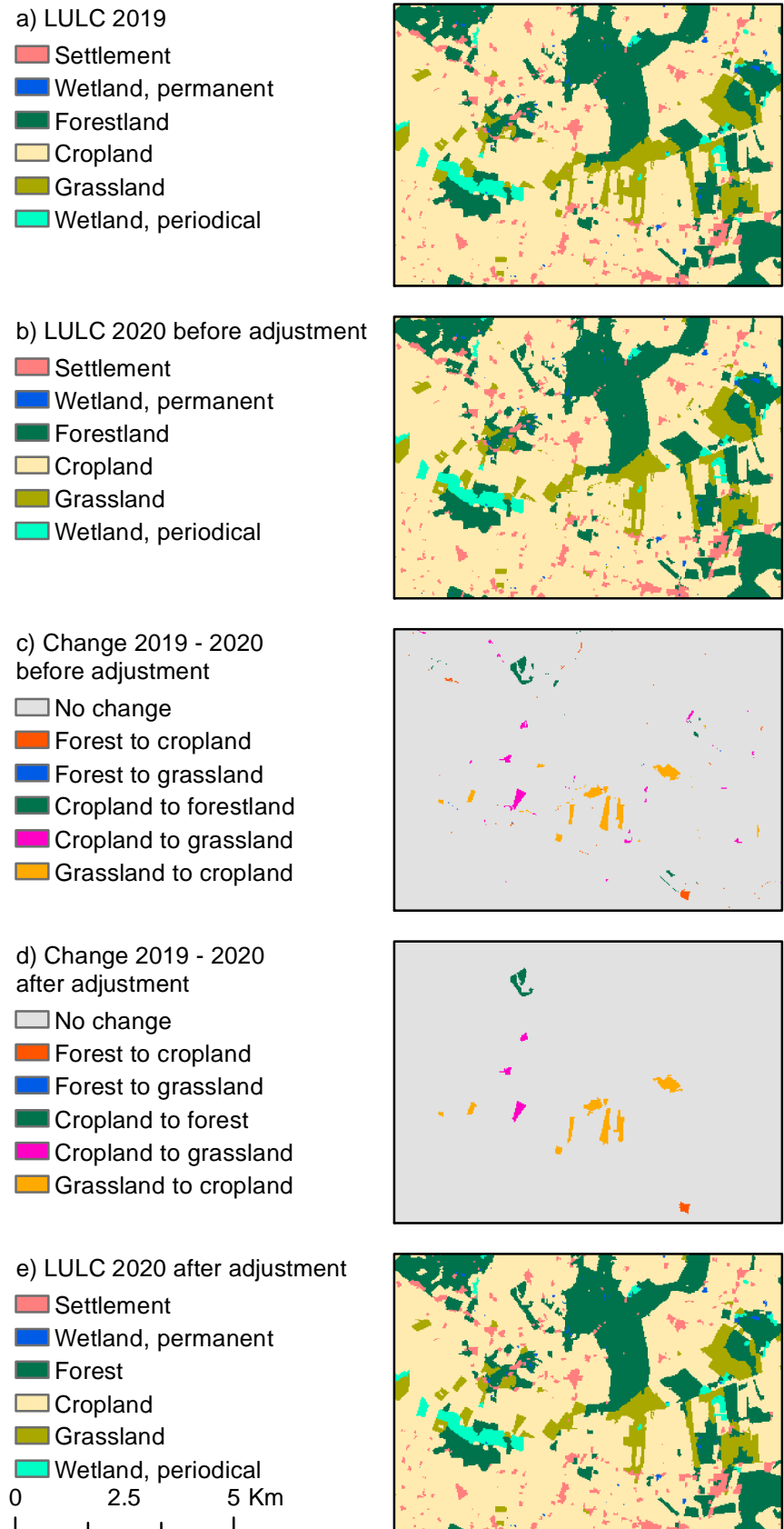
d) LULC 2020, adjusted

- Cropland
- Grassland
- Other



0 1,000 2,000 M.

Figure 5.3 Applied methodology for removal of narrow areas of LULC change illustrated for the period from 2019 to 2020. The LULC map for 2019 (a) is overlaid with the LULC map for 2020 (b) and areas with LULC changes are selected (c). Areas with change with a width ≤ 50 meters are removed (d) resulting in an adjusted LULC map for 2020 (e).



6 Land cover and land use changes

6.1 Total changes since 1990

For the period from 1990 to 2020, the charts in Figure 6.1 show changes for the different LULC categories. Overall, LULC changes are characterised by a decrease of the Cropland area and an increase of the other categories. The total Cropland area decreased by around 195,000 ha or 6.5 %. The total Grassland area increased by around 26,000 ha or 18.6 %. Until 2013, the area of Grassland was fairly stable and then increased considerable until 2017. The total area of Forestland increased by around 96,800 ha or 17.8 % with the largest increase until 2013. The total area of Settlement increase by around 52,000 ha or 10.8 % with the largest increase after 2005. Wetland, partly water covered increased by around 19,000 ha or 37.9 %, while Wetland, fully water covered increased by around 6,000 ha or 11.6 %.

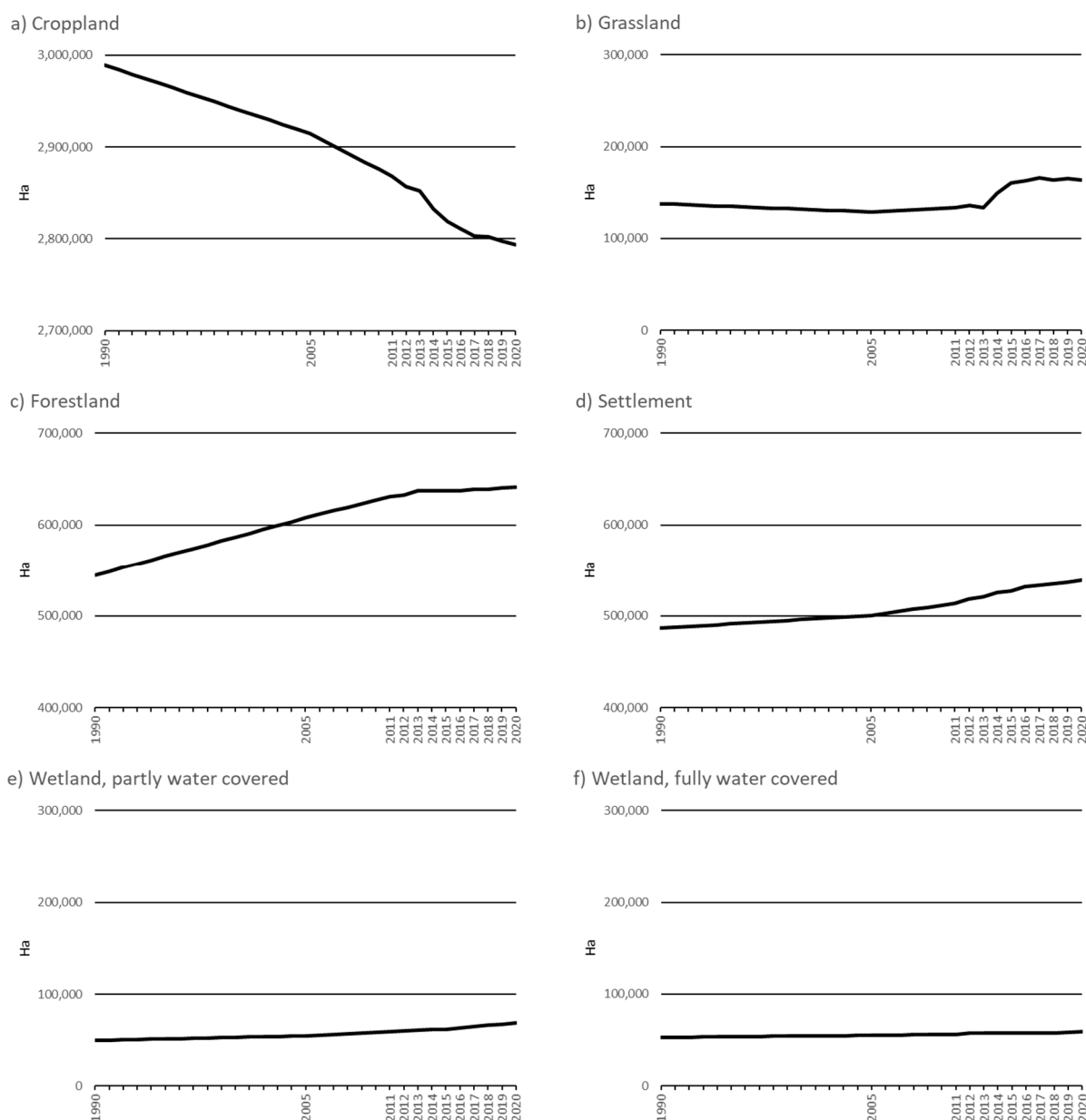


Figure 6.1 Total LULC change from 1990 – 2020 for different categories.

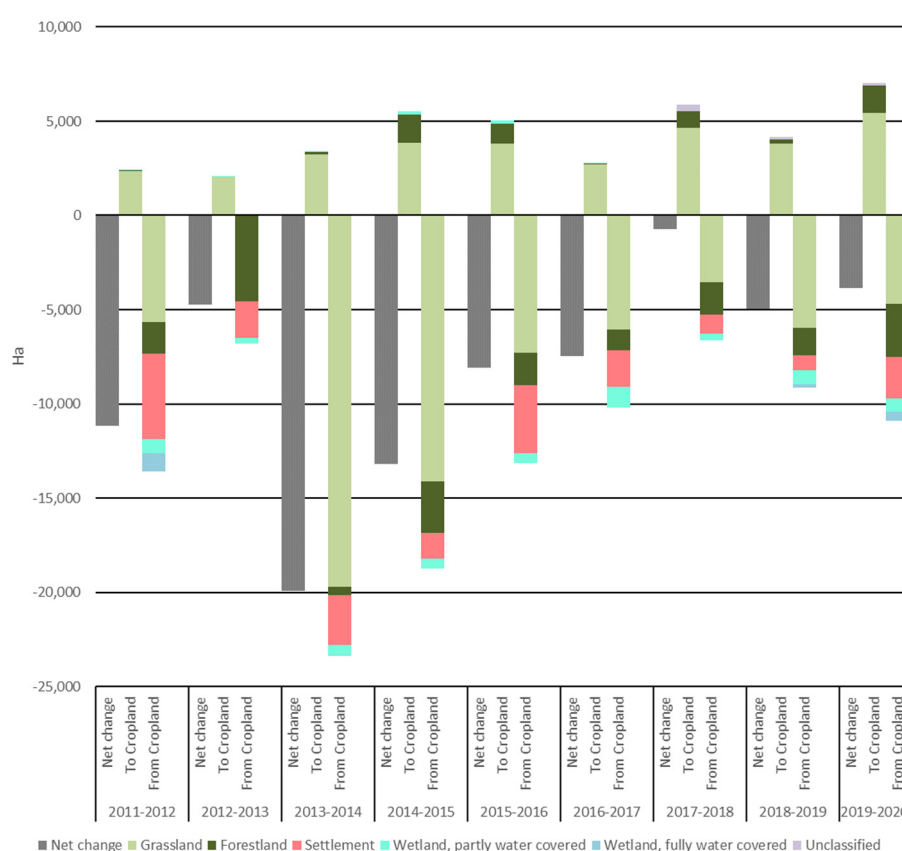
6.2 Annual dynamics after 2011

For selected LULC categories, Figures 6.2 to 6.4 show net- as well as relative annual changes for the period from 2011 to 2020. The figures elucidate that net-changes comprise both increases and decreases in area.

6.2.1 Cropland

Over the whole period, net-changes in Cropland were negative (Figure 6.2). However, the negative net-change comprises both areas where cropland was converted to other LULC categories (loss) and areas, where other LULC categories were converted to Cropland (gain). Cropland loss was due to conversion to Grassland, Forestland, Settlement, Wetland, partly water covered and Wetland, fully water covered. Cropland gain was mainly due to conversion from Grassland and to a minor extend from Forestland, Wetland, partly water covered and previously unclassified land.

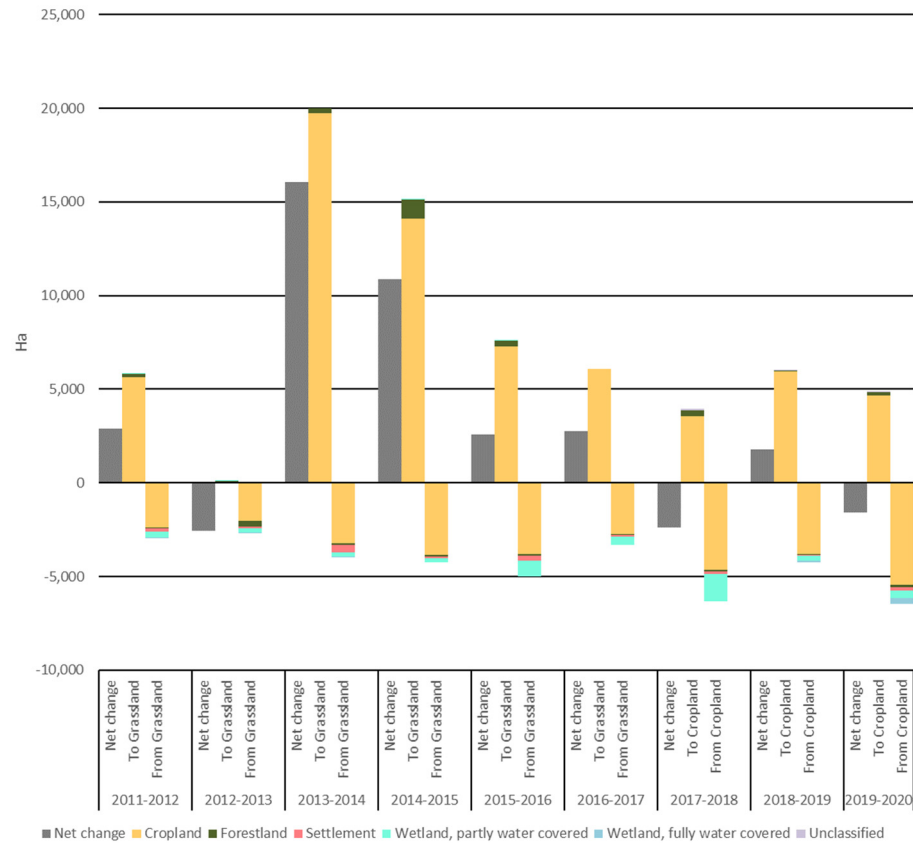
Figure 6.2 Cropland dynamics. Annual net-changes, gains, and losses from 2011 to 2020.



6.2.2 Grassland

Over most of the period from 2011 to 2020, net-changes in Grassland were positive (Figure 6.3). Grassland gain was mainly due to conversion from Cropland and some conversion from Forestland. Grassland loss was mainly due to conversion to Cropland and to a minor degree due to conversion to Forestland, Settlement and Wetland, partly water covered.

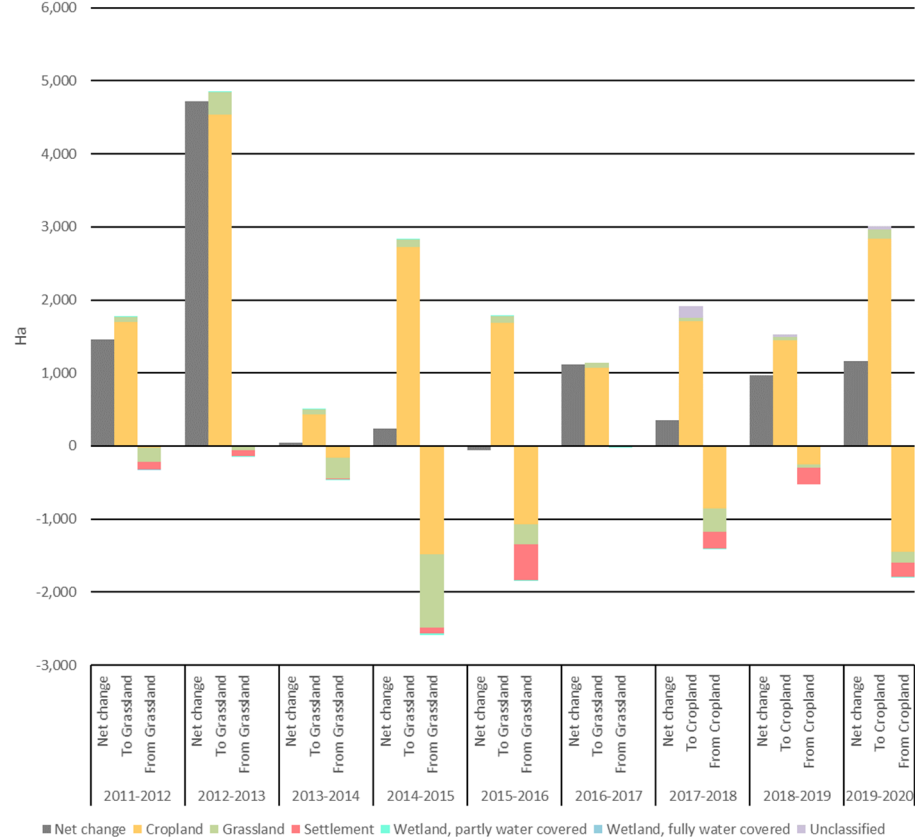
Figure 6.3 Grassland dynamics. Annual net-changes, gains, and losses from 2011 to 2020.



6.2.3 Forestland

Between 2011 and 2020, annual net-changes for forestland were both positive and negative (Figure 6.4). Gains in Forestland are mainly due to conversion from Cropland and to a minor degree due to conversion from Grassland and from unclassified land. Losses in Forestland are mainly due to conversion to Cropland and to Grassland and to a minor degree due to conversion to Settlement and to Wetland, partly water covered.

Figure 6.4 Forestland dynamics. Annual net-changes, gains, and losses from 2011 to 2020.



The relatively large loss of Forestland to Cropland and Grassland is to some degree a result of the applied data. While for the years 1990, 2005 and 2011, the layer for forestland mainly based on Landsat satellite images (Levin et al. 2014) the mapping of LULC changes after 2011 is based on existing categorical (i.e. pre-classified) geo-graphical information. Furthermore, applied field parcel maps often contain parcels, which were not earlier registered. As a consequence, areas, which based on the Landsat satellite images are mapped as deforestation, in cases, where new field parcels with an object type excluding forest appear. In 2018 a validation of mapped LULC changes, based on interpretation of aerial photos was carried out (Johansen et al. 2018). For a total of 998 sample point which were mapped as deforestation in the period from 2014 to 2015 and from to 2015 to 2016, it was estimated that about 50 % of the points did not meet the requirements for Forestland prior to deforestation. I.e., for these points, the mapped deforestation was a consequence of an imprecise mapping of Forestland based on satellite images.

Table 6.1 summarises the total area and area proportion, which for the period from 2011 to 2020 was mapped as conversion from Forestland to either Grassland or Cropland. Of the total area of approx. 6,500 ha, around 4,000 ha (~62 %) were Forestland, which was not earlier covered by the field parcel map and thus most probably are the consequence of errors in the Forestland layer derived from satellite images. Around 1,100 ha (~17 %) were energy forest (poplar or alder) or Christmas trees while around 2,500 ha (~38 %) were other Forestland derived from the field parcel maps. These numbers indicate that, because of the applied data and methodology, the total area of deforestation is substantially overestimated.

Table 6.1 Total area and area proportion mapped as conversion from Forestland to Cropland or Grassland in the period from 2011 to 2020.

	Area (ha)	Area proportion (%)
Energy forest	282	4.3
Christmas trees	848	13.1
Other Forestland earlier in field parcel map	2,464	37.9
Other Forestland not earlier in field parcel map	4,031	62.1
Total	6,495	100.0

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Appendix

Applied object types from field parcel maps and agricultural registers from 2008 to 2020 and aggregation to LULC categories for the years 2012 to 2020.

Original object code	Original object name (Danish)	Original object name (English)	LULC category code	LULC category name	Forest allowed	Wetland allowed
1	Vårbyg	Spring barley	15	Cropland	no	no
2	Vårhvede	Spring wheat	15	Cropland	no	no
3	Vårhavre	Spring oat	15	Cropland	no	no
4	Blanding af vårsåede arter	Mixture of spring cereals	15	Cropland	no	no
5	Majs til modenhed	Maize to maturity	15	Cropland	no	no
6	Vårhvede, brødhvede	Spring wheat, near cereal	15	Cropland	no	no
7	Korn + bælgssæd under 50% bælgssæd	Cereal/pulse, max. 50% pulse	15	Cropland	no	no
8	Vårspelt	Spring spelt	15	Cropland	no	no
9	Vinterspelt	Wither spelt	15	Cropland	no	no
10	Vinterbyg	Winter barley	15	Cropland	no	no
11	Vinterhvede	Winter wheat	15	Cropland	no	no
13	Vinterhvede, brødhvede	Wither wheat, near cereal	15	Cropland	no	no
14	Vinterrug	Winter rye	15	Cropland	no	no
15	Vinterhybridrug	Wither hybrid rye	15	Cropland	no	no
16	Vintertriticale	Winter triticale	15	Cropland	no	no
17	Blanding af efterårssåede arter	Mixture of winter cereals	15	Cropland	no	no
21	Vårraps	Spring rape	15	Cropland	no	no
22	Vinterraps	Winter rape	15	Cropland	no	no
23	Rybs	Rape	15	Cropland	no	no
24	Solsikke	Sunflower	15	Cropland	no	no
25	Sojabønner	Soy bean	15	Cropland	no	no
30	Ærter	Pea	15	Cropland	no	no
31	Hestebønner	Broad bean	15	Cropland	no	no
32	Sødlupin	Lupine	15	Cropland	no	no
35	Bælgssæd, flerårig blanding	Pulse seed, perennial	15	Cropland	no	no
36	Bælgssæd, andre typer til modenhed blanding	Other pulse seed to maturity	15	Cropland	no	no
40	Oliehør	Flax grown as an oilseed crop	15	Cropland	no	no
41	Spindhør	Flax grown for textile	15	Cropland	no	no
42	Hamp	Hemp	15	Cropland	no	no
50	Anden bredbladet afgrøde	Other wide-leaf crops	15	Cropland	no	no
51	Blanding bredbladet afgrøde, frø/kerne	Mixture of wide-leaf crops, seed	15	Cropland	no	no
52	Quinoa	Quinoa	15	Cropland	no	no
53	Boghvede	Buckwheat	15	Cropland	no	no
54	Bælgssæd blanding	Pulse seed, mixture	15	Cropland	no	no
55	Vårrug	Spring rye	15	Cropland	no	no
56	Vårtriticale	Spring triticale	15	Cropland	no	no
57	Vinterhavre	Winter oat	15	Cropland	no	no
58	Sorghum	Sorghum	15	Cropland	no	no
101	Rajgræsfrø, alm.	Rai grass seed	15	Cropland	no	no

102	Rajgræsfrø, alm. 1. år, efterårsudlagt	Rai grass seed, 1st year, fall planted	15	Cropland	no	no
103	Rajgræsfrø, ital.	Italian rai grass seed	15	Cropland	no	no
104	Rajgræsfrø, ital. 1. år efterårsudlagt	Italian rai grass seed, 1st year, fall planted	15	Cropland	no	no
105	Timothefrø	Timothy seed	15	Cropland	no	no
106	Hundegræsfrø	Orchard grass seed	15	Cropland	no	no
107	Engsvingelfrø	Fescue grass seed	15	Cropland	no	no
108	Rødsvingelfrø	Red fescue seed	15	Cropland	no	no
109	Rajsvingelfrø	Festulolium	15	Cropland	no	no
110	Svingelfrø, stivbladet	Stiff-leaved festuca seed	15	Cropland	no	no
111	Svingelfrø, strand-	Festuca littorea seed	15	Cropland	no	no
112	Engrapgræsfrø (marktype)	Smooth meadow grass seed (field type)	15	Cropland	no	no
113	Engrapgræsfrø (plænetype)	Smooth meadow grass seed (lawn type)	15	Cropland	no	no
114	Rapgræsfrø, alm.	Meadow grass seed	15	Cropland	no	no
115	Hvenefrø, alm. og krybende	Brown top/bent grass seed	15	Cropland	no	no
116	Rajgræs, hybrid	Rai grass, hybrid	15	Cropland	no	no
117	Rajgræs, efterårsudl. hybrid	Rai grass seed, fall planted, hybrid	15	Cropland	no	no
118	Rajsvingelfrø, efterårsudlagt	Festulolium, autumn planted	15	Cropland	no	no
120	Kløverfrø	Clover seed	15	Cropland	no	no
121	Bælgplanter, frø	Legume, seed	15	Cropland	no	no
122	Kommenfrø	Caraway seed	15	Cropland	no	no
123	Valmuefrø	Poppy seed	15	Cropland	no	no
124	Spinatfrø	Spinach seed	15	Cropland	no	no
125	Bederoefrø	Beet seed	15	Cropland	no	no
126	Blanding af markfrø til udsæd	Other seed for sowing	15	Cropland	no	no
149	Kartofler, lægge- (certificerede)	Seed potato (certified)	15	Cropland	no	no
150	Kartofler, lægge- (egen opformering)	Seed potato (own generation)	15	Cropland	no	no
151	Kartofler, stivelses-	Starch potato	15	Cropland	no	no
152	Kartofler, spise	Potato for consumption	15	Cropland	no	no
153	Kartofler, andre	Potato other	15	Cropland	no	no
154	Kartofler, spise- (proces, skrællede kogte)	Potato for consumption (peeled and boiled)	15	Cropland	no	no
155	Kartofler, pulver/granules-	Potato for powder	15	Cropland	no	no
156	Kartofler, friteret/chips/pommes frites	Potato for fried potatoes, chips	15	Cropland	no	no
160	Sukkerroer til fabrik	Beet for industry	15	Cropland	no	no
161	Cikorierødder	Chicory root	15	Cropland	no	no
162	Blanding, andre industriafrø.	Mixture, other industrial crops	15	Cropland	no	no
170	Græs til fabrik (omdrift)	Grass/clover for industry (in rotation)	15	Cropland	no	no
171	Lucerne, slæt	Lucerne, harvest	15	Cropland	no	no
172	Lucernegræs, over 25% græs til slæt inkl. eget foder	Lucerne grass, > 25% grass for harvest, incl. own fodder	15	Cropland	no	no
173	Kløver til slæt	Clover for harvest	15	Cropland	no	no
174	Kløvergræs til fabrik	Clover grass for industry	15	Cropland	no	no
180	Gul sennep	White mustard	15	Cropland	no	no
181	Anden oliefrøart	Other oil seed	15	Cropland	no	no
182	Blanding af oliearter	Mixture of oil seeds	15	Cropland	no	no
210	Vårbyg, helsæd	Spring barley, whole crop	15	Cropland	no	no

211	Vårhvede, helsæd	Spring wheat, whole crop	15	Cropland	no	no
212	Vårhavre, helsæd	Oat, whole crop	15	Cropland	no	no
213	Blandkorn, vårsået, helsæd	Dredge corn, spring planted, whole crop	15	Cropland	no	no
214	Korn og bælg-sæd, helsæd, under 50% bælg-sæd	Cereal and pulse, whole, < 50% pulse	15	Cropland	no	no
215	Ærte-helsæd	Pea, whole crop	15	Cropland	no	no
216	Silomajs	Silo maize	15	Cropland	no	no
220	Vinterbyg, helsæd	Winter barley, whole crop	15	Cropland	no	no
221	Vinterhvede, helsæd	Winter wheat, whole crop	15	Cropland	no	no
222	Vinterrug, helsæd	Winter rye, whole crop	15	Cropland	no	no
223	Vintertriticale, helsæd	Winter triticale, whole crop	15	Cropland	no	no
224	Blandkorn, efterårssået helsæd	Dredge corn, fall planted, whole crop	15	Cropland	no	no
230	Blanding af vårkorn, grønkorn	Spring cereal, green grain	15	Cropland	no	no
234	Korn og bælg-sæd, grønkorn, under 50% bælg-sæd	Cereal/pulse, green grain, < 50% pulse	15	Cropland	no	no
235	Blanding af vinterkorn, grønkorn	Mixture of winter cereal, green grain	15	Cropland	no	no
247	Miljøgræs MVJ-tilsagn (0 N), omdrift	Environmental grass (0 N), in rotation	16	Grassland	no	no
248	Permanent græs ved vandboring	Permanent grass at water drilling	16	Grassland	no	no
249	Udnyttet græs ved vandboring	Cultivated grass at water drilling	15	Cropland	no	no
250	Permanent græs, meget lavt udbytte	Permanent grass, very low yield	16	Grassland	yes	no
251	Permanent græs, lavt udbytte	Permanent grass, low yield	15	Cropland	yes	no
252	Permanent græs, normalt udbytte	Permanent grass, normal yield	15	Cropland	yes	no
253	Miljøgræs MVJ-tilsagn (80 N), omdrift	Environmental grass (max 80 tonnes N)	15	Cropland	no	no
254	Miljøgræs MVJ-tilsagn (0 N), permanent	Environmental grass (0 N)	16	Grassland	yes	no
255	Permanent græs, under 50% kløver/lucerne	Permanent grass, <50% clover/lucerne	15	Cropland	no	no
256	Permanent kløvergræs, over 50% kløver/lucerne	Permanent clover grass, >50% clover/lucerne	15	Cropland	no	no
257	Permanent græs, uden kløver	Permanent grass, no clover	15	Cropland	no	no
258	Permanent græs, ø-støtte	Permanent grass, organic farming subsidy	15	Cropland	no	no
259	Permanent græs, fabrik, over 6 tons	Permanent grass for industry, > 6 tonnes yield	15	Cropland	no	no
260	Græs med kløver/lucerne, under 50 % bælgpl. (omdrift)	Clover grass, <50% clover (in rotation)	15	Cropland	no	no
261	Kløvergræs, over 50% kløver (omdrift)	Clover grass, >50% clover (in rotation)	15	Cropland	no	no
262	Lucernegræs, over 50% lucerne (omdrift)	Lucerne grass >50% lucerne (in rotation)	15	Cropland	no	no
263	Græs uden kløvergræs (omdrift)	Grass without clover grass (in rotation)	15	Cropland	no	no
264	Græs og kløvergræs uden norm, under 50 % kløver (omdrift)	Grass and clover grass without N-norm, <50% clover (in rotation)	15	Cropland	no	no
265	Græs og kl. græs slået før vårsåede afg.	Grass and clover grass prior to spring crop	15	Cropland	no	no
266	Græs under 50% kløver/lucerne, ekstremt lavt udbytte (omdrift)	Grass <50% clover/lucerne, extremely low yield (in rotation)	16	Grassland	no	no
267	Græs under 50% kløver/lucerne, meget lavt udbytte (omdrift)	Grass <50% clover/lucerne, very low yield (in rotation)	15	Cropland	no	no
268	Græs under 50% kløver/lucerne, lavt udbytte (omdrift)	Grass <50% clover/lucerne, low yield (in rotation)	15	Cropland	no	no
269	Græs, rullegræs	Turf	15	Cropland	no	no
270	Græs til udegrise, omdrift	Grass for outdoor pigs, in rotation	15	Cropland	no	no

271	Rekreative formål	Areas for recreation purposes	16	Grassland	yes	no
272	Permanent græs til fabrik	Permanent grass for industry	15	Cropland	no	no
273	Lucerne til fabrik	Lucerne for industry	15	Cropland	no	no
274	Permanent lucernegræs over 25% græs, til fabrik	Permanent lucerne, >25% grass, for industry	15	Cropland	no	no
275	Rullegræs, perm. Græs	Permanent turf	15	Cropland	no	no
276	Permanent græs og kløvergræs uden norm, under 50 % kløver	Permanent grass/clover grass without N-norm, <50% clover	16	Grassland	yes	no
277	Kløver til fabrik	Clover for industry	15	Cropland	no	no
278	Permanent lucerne og lucernegræs over 50% lucerne	Permanent grass and lycerne grass, >50% lucerne	15	Cropland	no	no
279	Permanent kløvergræs til fabrik	Permanent clover grass for industry	15	Cropland	no	no
280	Fodersukkerroer	Sugar cane, fodder	15	Cropland	no	no
281	Kålroer	Swede	15	Cropland	no	no
282	Fodermarvkål	Marrow-stem kale	15	Cropland	no	no
283	Fodergulerødder	Carrot, fodder	15	Cropland	no	no
284	Græs med vikke og andre bælgplanter, under 50 % bælgpl.	Grass with pulses, >50 % pulses	15	Cropland	no	no
285	Græs og kløvergræs uden norm, over 50 % kløver (omdrift)	Grass and clover grass without N-norm, >50 % clover (in rotation)	15	Cropland	no	no
286	Permanent græs og kløvergræs uden norm, over 50 % kløver	Permanent grass and clover grass without N-norm, >50 % clover	16	Grassland	yes	no
287	Græs til udegrise, permanent	Grass for outdoor pigs, permanent	15	Cropland	no	no
305	Permanent græs, uden udbetaling af økologi-tilskud	Permanent grass without payment of subsidies for organic management	16	Grassland	no	no
306	Græs i omdrift, uden udbetaling af økologi-tilskud	Rotational grass without payment of subsidies for organic management	15	Cropland	no	no
308	MFO-brak, sommerslåning	Environmental focus area with fallow, summer mowing	15	Cropland	no	no
309	Udyrket areal ved vandboring	Uncultivated area at water drilling	16	Grassland	no	no
310	Brak, sommerslåning	Fallow, summer mowing	15	Cropland	no	no
311	Skovrejsning på tidl. landbrugsjord 1	Afforestation on former agricultural land	13	Forest	yes	no
312	20-årig udtagning	20 years set-aside	16	Grassland	yes	no
313	20-årig udtagning af agerjord med frivillig skovrejsning	20 years set-aside with voluntary afforestation	13	Forest	yes	no
314	20-årig udtagning med tilsagn om skovrejsning	20 years set-aside with approval for afforestation	13	Forest	yes	no
315	Miljøgræs brugt som udtagning	Environmental grass for set-aside	16	Grassland	no	no
316	Udtagning med fastholdelse, ej landbrugsareal	Wetland or low-lying areas with set-aside, not agricultural land	16	Grassland	no	yes
317	Vådområder med udtagning	Wetland for set-aside	17	Wetland	no	yes
318	MVJ ej udtagning, ej landbrugsareal	Agri-envrionmental scheme, no set-aside, not agricultural land	16	Grassland	yes	yes
319	MFO-brak, Udtagning, ej landbrugsareal	Agri-envrionmental scheme, set-aside, not agricultural land	16	Grassland	no	yes
320	Braklagte randzoner	Fallow in buffer zones	15	Cropland	no	no
321	Miljøtiltag, ej landbrugsarealer	Environmental initiative, not agricultural land	16	Grassland	no	yes
322	Minivådområder, projektilsagn	Mini wetlands, approved	17	Wetland	no	yes
323	MFO-udyrtet areal ved vandboring	Environmental focus area at water drilling	15	Cropland	no	no
324	Blomsterbrak	Flower fallow	15	Cropland	no	no
325	MFO-Blomsterbrak	Environmental focus area with flower fallow	15	Cropland	no	no

326	Ej landbrug, MSO, omlagt fra permanent græs	Environmental focus area, not agriculture, converted from permanent grass	16	Grassland	no	no
327	MFO-bræmme, sommerslåning	Environmental focus area, fringe with summer mowing	15	Cropland	no	no
328	MFO-bræmme med blomsterblanding	Environmental focus area, fringe with flower mix	15	Cropland	no	no
329	MFO-bræmme, miljøtilsagn	Environmental focus area, fringe with environmental approval	15	Cropland	no	no
334	MFO-bræmme, forårsslåning	Environmental focus area, fringe with spring mowing	15	Cropland	no	no
335	MFO-bræmme, permanent græs, forårsslåning	Environmental focus area, fringe with permanent grass, spring mowing	16	Grassland	no	no
336	MFO-bræmme, permanent græs, sommerslåning	Environmental focus area, fringe with permanent grass, summer mowing	16	Grassland	no	no
337	MFO-bræmme, permanent græs, miljøtilsagn	Environmental focus area, fringe with permanent grass, environmental approval	16	Grassland	no	no
338	Brak, forårsslåning	Fallow, spring mowing	15	Cropland	no	no
339	MFO-brak, forårsslåning	Environmental focus area, fallow, spring mowing	15	Cropland	no	no
340	Randzoneordningen	Buffer zones	15	Cropland	no	no
341	Randzoneordning med udtagning	Buffer zones with set-aside	15	Cropland	no	no
342	Bestøverbrak	Pollinator fallow	15	Cropland	no	no
343	MFO-bestøverbrak	Environmental focus area, pollinator fallow	15	Cropland	no	no
344	Brak langs vandløb og søer, forårsslåning (alternativ til efterafgrøder)	Fallow along watercourses and lakes, spring mowing (alternative to catch crop)	15	Cropland	no	no
345	Brak langs vandløb og søer, sommerslåning (alternativ til efterafgrøder)	Fallow along watercourses and lakes, summer mowing (alternative to catch crop)	15	Cropland	no	no
346	Brak, sommerslåning (til målrettet kvælstofregulering)	Fallow, summer mowing (for targeted nitrate regulation)	15	Cropland	no	no
347	Brak, forårsslåning (til målrettet kvælstofregulering)	Fallow, spring mowing (for targeted nitrate regulation)	15	Cropland	no	no
348	Brak langs vandløb og søer, forårsslåning (til målrettet kvælstofregulering)	Fallow along watercourses and lakes, spring mowing (for targeted nitrate regulation)	15	Cropland	no	no
349	Brak langs vandløb og søer, sommerslåning (til målrettet kvælstofregulering)	Fallow along watercourses and lakes, summer mowing (for targeted nitrate regulation)	15	Cropland	no	no
350	Miljøgræs med N-kvote	Environmental grass with nitrate quota	15	Cropland	no	no
360	Vildtafgrøder	Game crop	15	Cropland	no	no
400	Asieagurker	Gherkins	15	Cropland	no	no
401	Asparges	Asparagus	15	Cropland	no	no
402	Bladselleri	Celery	15	Cropland	no	no
403	Blomkål	Cauliflower	15	Cropland	no	no
404	Broccoli	Broccoli	15	Cropland	no	no
405	Courgette, squash	Courgette, squash	15	Cropland	no	no
406	Grønkål	Borecole	15	Cropland	no	no
407	Gulerod	Carrot	15	Cropland	no	no
408	Hvidkål	Cabbage	15	Cropland	no	no
409	Kinakål	Chinese cabbage	15	Cropland	no	no
410	Knoldselleri	Celeriac, turnip-rooted celery	15	Cropland	no	no
411	Løg	Onion	15	Cropland	no	no

412	Pastinak	Parsnip	15	Cropland	no	no
413	Rodpersille	Hamburg parsley	15	Cropland	no	no
415	Porre	Leek	15	Cropland	no	no
416	Rosenkål	Sprouts	15	Cropland	no	no
417	Rødbede	Beetroot	15	Cropland	no	no
418	Rødkål	Red cabbage	15	Cropland	no	no
420	Salat (friland)	Salad, outdoors	15	Cropland	no	no
421	Savoykål, spidskål	Savoy cabbage, pointed cabbage	15	Cropland	no	no
422	Spinat	Spinach	15	Cropland	no	no
423	Sukermajs	Sweet corn	15	Cropland	no	no
424	Ærter, konsum	Peas, consumption	15	Cropland	no	no
429	Jordskokker, konsum	Jerusalem artichoke, consumption	15	Cropland	no	no
430	Bladpersille	Leaf parsley	15	Cropland	no	no
431	Purløg	Chive	15	Cropland	no	no
432	Krydderurter (undtagen persille og purløg)	Herbs (not parsley or chives)	15	Cropland	no	no
433	Krydderurter, andre	Herbs, other	15	Cropland	no	no
434	Grøntsager, andre (friland)	Vegetable, other, outdoors	15	Cropland	no	no
440	Solhat	Coneflower	15	Cropland	no	no
448	Medicinpl., en- og toårige	Medicine plant, annual and bien- nial	15	Cropland	no	no
449	Medicinpl., stauder	Medicine plant, perennial	15	Cropland	no	no
450	Grøntsager, blandinger	Vegetable, mixtures	15	Cropland	no	no
486	Hønsegård uden plantedække	Chicken yard without vegetation cover	15	Cropland	no	no
487	Skovlandbrug	Agroforestry	13	Forest	yes	no
488	Hønsegård, permanent græs	Chicken yard, permanent grass	15	Cropland	no	no
489	Havtorn	Buckthorn	15	Cropland	no	no
491	Storfrugtet tranebær	Cranberry, large fruits	15	Cropland	no	no
493	Surbær	Chokeberry	15	Cropland	no	no
496	Medicinpl., vedplanter	Medicine plants, woody	15	Cropland	no	no
497	Planteskolekulturer, vedplanter, til videresalg	Nursery, woody plants for sale	15	Cropland	no	no
498	Containerplads 4, vedplanter	Container 4, woody plants	15	Cropland	no	no
499	Lukket system	Closed system	15	Cropland	no	no
500	Buske og træer	Bushes and trees	15	Cropland	no	no
501	Stauder	Herbaceous perennial	15	Cropland	no	no
502	Blomsterløg	Bulb	15	Cropland	no	no
503	En- og to-årige planter	Annual and biennial plants	15	Cropland	no	no
504	Solbær, stiklingeopformering	Blackcurrant, cuttings	15	Cropland	no	no
505	Ribs, stiklingeopformering	Redcurrant, cuttings	15	Cropland	no	no
506	Stikkelsbær, stiklingeopformering	Gooseberry, cuttings	15	Cropland	no	no
507	Hindbær, stiklingeopformering	Raspberry, cuttings	15	Cropland	no	no
508	Andre af slægten Vaccinium	Other of genus Vaccinium	15	Cropland	no	no
509	Trækvæde	Quince	15	Cropland	no	no
510	Melon	Melon	15	Cropland	no	no
511	Græskar	Pumpkin	15	Cropland	no	no
512	Rabarber	Rhubarb	15	Cropland	no	no
513	Jordbær	Strawberry	15	Cropland	no	no
514	Solbær	Blackcurrant	15	Cropland	no	no
515	Ribs	Redcurrant	15	Cropland	no	no

516	Stikkelsbær	Gooseberry	15	Cropland	no	no
517	Brombær	Blackberry	15	Cropland	no	no
518	Hindbær	Raspberry	15	Cropland	no	no
519	Blåbær	Blueberry	15	Cropland	no	no
520	Surkirsebær uden undervækst af græs	Cherry without undergrowth of grass	15	Cropland	no	no
521	Surkirsebær med undervækst af græs	Cherry with undergrowth of grass	15	Cropland	no	no
522	Blomme uden undervækst af græs	Plum without undergrowth of grass	15	Cropland	no	no
523	Blomme med undervækst af græs	Plum with undergrowth of grass	15	Cropland	no	no
524	Sødkirsebær uden undervækst af græs	Sweet cherry without undergrowth of grass	15	Cropland	no	no
525	Sødkirsebær med undervækst af græs	Sweet cherry with undergrowth of grass	15	Cropland	no	no
526	Hyld	Elder	15	Cropland	no	no
527	Hassel	Hazel	15	Cropland	no	no
528	Æbler	Apple	15	Cropland	no	no
529	Pærer	Pear	15	Cropland	no	no
530	Vindrue	Grape	15	Cropland	no	no
531	Anden træfrugt	Other tree fruit	15	Cropland	no	no
532	Anden buskfrugt	Other bush fruit	15	Cropland	no	no
533	Rønnebær	Rowanberry	15	Cropland	no	no
534	Hyben	Hip	15	Cropland	no	no
536	Spisedruer	Grapes for consumption	15	Cropland	no	no
537	Valnød (almindelig)	Walnut (common)	15	Cropland	no	no
538	Kastanje (ægte)	Chestnut (true)	15	Cropland	no	no
539	Blandet frugt	Mixed fruits	15	Cropland	no	no
540	Tomater	Tomatoes	15	Cropland	no	no
541	Agurker	Cucumber	15	Cropland	no	no
542	Salat (drivhus)	Lettuce (greenhouse)	15	Cropland	no	no
543	Grøntsager, andre (drivhus)	Other vegetables (greenhouse)	15	Cropland	no	no
544	Snitblomster og snitgrønt	Cut flower/sprigs	15	Cropland	no	no
545	Potteplanter	Pot plants	15	Cropland	no	no
547	Planteskolekulturer, stauder	Nursery, perennial/woody plants	15	Cropland	no	no
548	Småplanter, en-årige	Minor plants, annual	15	Cropland	no	no
549	Lukket system 1, en-årige	Closed system 1, annual	15	Cropland	no	no
550	Lukket system 2, stauder	Closed system 2, perennial/woody plants	15	Cropland	no	no
551	Moskusgræskar	Musk pumpkin	15	Cropland	no	no
552	Mandelgræskar	Almond pumpkin	15	Cropland	no	no
553	Centnergræskar	Bitter pumpkin	15	Cropland	no	no
560	Containerplads 1, frugtbuske	Container 1, fruit bushes	15	Cropland	no	no
561	Containerplads 2, en-årige	Container 2, annual	15	Cropland	no	no
562	Containerplads 3 (stauder og vedpl.)	Container 2, herbaceous perennial and woody plants	15	Cropland	no	no
563	Svampe, champignon	Mushroom	15	Cropland	no	no
564	Containerplads	Container	15	Cropland	no	no
570	Humle	Hop	15	Cropland	no	no
576	Skovrejsning (statslig) - forbedring af vandmiljø og grundvandsbeskyttelse	Afforestation (state) - improvement of aquatic environment and groundwater protection	13	Forest	yes	no
577	Skov med biodiversitetsformål	Forest for biodiversity protection	13	Forest	yes	no

578	Skovrejsning (privat) - forbedring af vandmiljø og grundvandsbeskyttelse	Afforestation- improvement of aquatic environment and groundwater protection	13	Forest	yes	no
579	Tagetes, sygdomssanerende plante	Tagetes	15	Cropland	no	no
580	Anden skovdrift	Other forestry	13	Forest	yes	no
581	Skovdrift med fjernelse af ved	Forestry with removal of wood	13	Forest	yes	no
582	Pyntegrønt, økologisk jordbrug	Decorative greenery, organic	13	Forest	yes	no
583	Juletræer og pyntegrønt	Christmas tree, decorative greenery	13	Forest	yes	no
584	Juletræer i fredsskov	Christmas trees in forest reserve	13	Forest	yes	no
585	Skovrejsning i projektområde, som ikke er omfattet af tilsagn	Afforestation in project area without approval for subsidy	13	Forest	yes	no
586	Offentlig skovrejsning	Public afforestation	13	Forest	yes	no
587	Skovrejsning på tidl. landbrugsjord 3	Afforestation on former agricultural land	13	Forest	yes	no
588	Statslig skovrejsning	State afforestation	13	Forest	yes	no
589	Bæredygtig skovdrift	Sustainable afforestation	13	Forest	yes	no
590	Bæredygtig skovdrift i Natura 2000-område	Sustainable afforestation within Natura2000 designation	13	Forest	yes	no
591	Lavskov	Coppice forest	15	Cropland	no	no
592	Pil	Willow	15	Cropland	no	no
593	Poppel (0-100 andre træer pr. ha)	Poplar (100-400 other trees pr. Ha)	13	Forest	yes	no
594	El	Alder	13	Forest	yes	no
596	Elefantgræs	Elephant grass	15	Cropland	no	no
597	Rørgræs	Reed grass	15	Cropland	no	no
598	Sorrel	Sorrel	15	Cropland	no	no
599	Poppel (100-400 andre træer pr. ha)	Poplar (100-400 other trees pr. Ha)	13	Forest	yes	no
602	MFO - Pil	Willow on environmental focus sites	15	Cropland	no	no
603	MFO - Poppel (0-100 andre træer pr. ha)	Poplar on environmental focus sites (100-400 other trees pr. Ha)	13	Forest	yes	no
604	MFO - El	Alder on environmental focus sites	13	Forest	yes	no
605	MFO - Lavskov	Coppice on environmental focus sites	15	Cropland	no	no
650	Chrysanthemum Garland, frø	Chrysanthemum Garland, seed	15	Cropland	no	no
651	Dildfrø	Dill seed	15	Cropland	no	no
652	Kinesisk kålfrø	Chinese kale seed	15	Cropland	no	no
653	Karsefrø	Cress seed	15	Cropland	no	no
654	Rucolafrø	Rocket seed	15	Cropland	no	no
655	Radisefrø (inklusive olieræddikefrø)	Radish seed	15	Cropland	no	no
656	Bladbedefrø, rødbedefrø	Leaf beet seed, beetroot seed	15	Cropland	no	no
657	Grønkålfrø	Borecole seed	15	Cropland	no	no
658	Gulerodsfrø	Carrot seed	15	Cropland	no	no
659	Kålfrø (hvid- og rødkål)	Cabbage seed (red and white cabbage)	15	Cropland	no	no
660	Persillefrø	Parsley seed	15	Cropland	no	no
661	Kørvelfrø	Chervil seed	15	Cropland	no	no
662	Majroe frø	Early garden turnip seed	15	Cropland	no	no
663	Pastinakfrø	Parsnip seed	15	Cropland	no	no
664	Skorzonerod/skorzonerodfrø	Viper's grass seed	15	Cropland	no	no
665	Havrerodfrø	Purple salsify seed	15	Cropland	no	no
666	Purløgsfrø	Chive seed	15	Cropland	no	no
667	Timianfrø	Thyme seed	15	Cropland	no	no

668	Blomsterfrø	Flower seed	15	Cropland	no	no
669	Andet havefrø	Other garden seed	15	Cropland	no	no
701	Grønkorn af vårbyg	Green grain from spring barley	15	Cropland	no	no
702	Grønkorn af vårhvede	Green grain from spring wheat	15	Cropland	no	no
703	Grønkorn af vårhavre	Green grain from spring oat	15	Cropland	no	no
704	Grønkorn af vårrug	Green grain from spring rye	15	Cropland	no	no
705	Grønkorn af vårtriticale	Green grain from spring triticale	15	Cropland	no	no
706	Grønkorn af vinterbyg	Green grain from winter barley	15	Cropland	no	no
707	Grønkorn af vinterhvede	Green grain from winter wheat	15	Cropland	no	no
708	Grønkorn af vinterhavre	Green grain from winter oat	15	Cropland	no	no
709	Grønkorn af vinterrug	Green grain from winter rye	15	Cropland	no	no
710	Grønkorn af hybridrug	Green grain from hybrid seed	15	Cropland	no	no
711	Grønkorn af vintertriticale	Green grain from winter triticale	15	Cropland	no	no
777	Ex-non-food brak	Ex-non-food fallow	15	Cropland	no	no
800	Andre arealer i skovblokke	Other areas in forest blocks	16	Grassland	no	no
801	Skov i IKKE skovblok	Forest outside forest blocks	13	Forest	yes	no
900	Øvrige afgrøder	Other cop	15	Cropland	no	no
901	Naturarealer efter driftsloven	Nature areas according to farming law	16	Grassland	no	no
902	Naturlignende arealer	Nature like areas	16	Grassland	no	no
903	Lysåbne arealer i skov	Open nature in protected forest	16	Grassland	no	no
904	Andre arealer i skovblokke	Other areas in forest blocks	16	Grassland	no	no
905	Anden anvendelse på tilsagnsarealer	Other land use on land with environmental subsidies	16	Grassland	no	no
907	Naturarealer, økologisk jordbrug	Nature area, organic agriculture	16	Grassland	yes	no
908	Naturarealer, ansøgning om miljøtilsagn	Nature area, application for environmental subsidies	16	Grassland	yes	no
920	Økologisk sommerbrak	Organic summer fallow	15	Cropland	no	no
921	Intern kode: Bar jord	Bare soil	15	Cropland	no	no
960	Græs, udlæg/eftersl. efter grønkorn o.l	Grass, autumn sown, after green grain	15	Cropland	no	no
961	Græs, udlæg/eftersl. eft.helsæd/tidl.frø	Grass, autumn sown, after whole grain	15	Cropland	no	no
962	Græs, udlæg/eftersl. eft.korn/sildig frø	Grass, autumn sown, after grain	15	Cropland	no	no
963	Kløvergræs, udlæg/eftersl.eft. grønkorn	Clover grass, autumn sown, after green grain	15	Cropland	no	no
964	Kløvergræs, udlæg/efterslæt efter helsæd	Clover grass, autumn sown, after whole grain	15	Cropland	no	no
965	Kløvergræs, udlæg/efterslæt efter korn	Clover grass, autumn sown, after grain	15	Cropland	no	no
968	Pligtige efterafgrøder	Mandatory catch crops	15	Cropland	no	no

ESTIMATING LAND USE/LAND COVER AND CHANGES IN DENMARK

Technical documentation for the assessment of annual
land use/land cover and changes since 2011

Due to Denmark's ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, Denmark is obliged to document sequestration and emission of carbon dioxide from land use and land cover and changes in these. According to the IPCC guidelines, estimation of land use and land cover must cover following land use and land cover categories: Settlement, Cropland, Grassland, Wetland, which is fully water covered, Wetland, which is partly water covered, Forestland and Other land. Since the first assessment for the period from 1990 to 2012 (Levin et al., 2014), several methodological adjustments have been compiled. This report documents and describes applied data and developed for estimating annual amounts and changes in land use and land cover for Denmark for the period from 2011 to 2020.