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|  | **Working document, V 1.1** |
| **Project/ Action** | EEA AMP2019 – 1.7.5.2 Ecosystem accounting and KIP-INCA support  |
| **Subaction** | Overview of methods and data used to develop spatial farming intensity data sets for use under the EU MAES and INCA projects – focus on nutrient accounts and High Nature Value (HNV) farmland analysis |
| **Partners involved** | UMA, UAB |
| **Date** | 10/10/2019 |
| **Prepared by:** | Christoph Schröder, Michael Weiss, Jan-Erik Petersen |
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# Introduction

The aim of this document is to provide an overview of input data of the CAPRI nitrogen budget dataset, its parameters and aggregates as well as processing steps done to extract spatial nitrogen accounts for Europe (with a focus on the EU-28, minus Croatia). A special section is dedicated to the spatial distribution of livestock data extracted from CAPRI, and used for the update of the EEA/JRC HNV farmland assessment.

These input data are used in the context of ecosystem accounting and as farming intensity parameters for as additional factor for the methodology to estimate the distribution and trends of High-Nature Value Farmland at European level.

The European nutrient accounts are based on the results provided by the CAPRI team of JRC. The Common Agricultural Policy Regional Impact (CAPRI) model consists of a supply and a market model and is used to estimate nitrogen balances at the level of Farm Structure Soil Units (FSU). The data used for the nitrogen balance relates to Disaggregated data from CAPRI time series with relevant elements for the Gross Nitrogen Surplus by crop at the spatial level of (FSU).

Besides land-use and crop information, livestock data are fundamental input data. The spatial distribution of the livestock information represents an important component of the HNV farmland assessment.

# Input data

The CAPRI (Common Agricultural Policy Regionalised Impact) model is a tool for ex ante impact assessment of agricultural and international trade policies with a focus on the European Union. As an economic partial comparative static equilibrium model for agriculture, its core consists of two interlinked modules: the supply module, covering about 280 regional aggregate programming models covering the EU-27, Norway and Western Balkans at the NUTS 2 level and the market module, a global spatial multi-commodity model for about 50 agricultural commodities, which together allow calculation of a wide range of economic and environmental indicators. A spatial downscaling component allows impact assessment at the FSU level for EU-27 (EU-28 minus Croatia).

Further detailed information on the purpose and set-up of CAPRI is available via this Wikipedia link: https://en.wikipedia.org/wiki/CAPRI\_model

Since Eurostat has released gridded FSS data sets for Commission internal use the CAPRI team has built on this data set for producing a more accurate estimate of the spatial distribution of agricultural activity in Europe (led by staff at JRC Ispra). This builds on producing gap-filled 10 x 10 km data sets on basic agricultural statistics (crop areas, livestock numbers). EUROSTAT provided crop and livestock statistics for 3 grid levels (10x10km grid, 20x10km grid and 60x60km grid) and 3 administrative levels (NUTS3, NUTS2, Country). The gridded FSS data provided by EUROSTAT is subject to confidentiality rules. Values have been removed where they represented data from less than 5 holdings in each individual grid cell, or where 1 or 2 holdings explain at least 85% of the information in the spatial unit. The higher the resolution, the more data was subject to confidentiality treatment (i.e. the higher the resolution the more crop area / livestock units were missing). The JRC Ispra CAPRI team used the information from the NUTS2/3, 60x60km and 20x20km grids to gap-fill the 10x10km grid data (for example areas of the single crops at 10km x 10km had to match the area of the crop at 20km by 20km and at 60km by 60km and at NUTS2/3 level).

The CAPRI nutrient balance relies on input data related to land use, manure and fertiliser input, atmospheric deposition, crop uptake etc. from different sources, but mainly based on official statistics (Eurostat) or sectoral information (e.g. fertiliser use). These data, available mainly at country level or NUTS2 level are transformed via disaggregation procedures that are described for each input in Table 1.

The table includes information about the data producer/source, spatial resolution/scale, availability of time series, disaggregation procedure etc. Potential options for future improvements of the CAPRI model are also mentioned.

Table 1: Overview of input data for CAPRI

| **Data and model inputs** | **Data producer / main data source** | **Spatial** **Resolution / countries covered** | **Time series / regularity** | **Any future improvement envisaged** | **Disaggregation process or other data preparation (if required)?****By whom and how ?** | **Data set owner (in context of producing derived data sets)** |
| --- | --- | --- | --- | --- | --- | --- |
| 1a) Land use(EU-28, minus Croatia) | LAPM (Land area processing module) | FSU (from CAPRI approach) | 2010 (based on availability of LUCAS data around FSS data set) |  | Multinomial log-it model using Corine and environmental drivers, calibrated at LUCAS observationshttps://bitbucket.org/xavi-rp/ludm\_new | JRC |
| 1b) Land use | FSS 10 km gap-filledi.e. Gridded Farm Structure Survey data (Eurostat) | 10km | 2010 (2000 if possible), every 10 years (envisaged) |  | Based on nested FSS data at 10x10 km2, 20x20 km2 and 60x60 km2, Nuts2 and Nuts3 keeping confidentiality rules. Gap-filled | Eurostat/JRC |
| 1c) Land use | CAPRI (i) constrained at 10 km; (ii) constrained at CAPRI NUTS2 | FSU (from CAPRI approach) | 2000-2012 (capri baseyear) + individual points until current year - 2 |  | Combining 1a and 1b – constraining 1a to 1b, then constraining result to CAPRI NUTS regions for base year, then to time series | JRC-CAPRI |
| 2a) N fertilizer application | Country data on use and application of mineral fertilizer | NUTS0 | Yearly |  |  | EFMA  |
| 2b) N fertilizer application | Mineral N application rate by crop | NUTS2 | Yearly |  |  | CAPRI team |
| 2c) N fertilizer application | Mineral N application rate by crop | FSU | Same as 1c |  | Disaggregated from 2b) | JRC-CAPRI |
| 3a) Livestock numbers | Gridded Farm Structure Survey data (Eurostat) – Gap-filled | 10km | 2010 (2000 envisaged), every 10 years |  | Further processing is currently required to integrate data set into CAPRI model / for other uses | Eurostat / CAPRI team |
| 3b) Animal livestock numbers | CAPRI livestock disaggregation | FSU | Reference year 2012 |  | CAPRI regional data building on Eurostat statistics, distinguishing dairy cattle, other cattle, sheep + goats, pigs, poultry and other cattle; disaggregation data from 3b)  | JRC-CAPRI |
| 3c) Livestock emissions | E-PRTR database of large pig and poultry farms | Point | 2007 onwards only? |  | To evaluate if data can be extracted and transformed to animal numbers or LU | EEA |
| 4a) Manure | Dynamic excretion rates  | NUTS0 | Yearly |  | Calculated as animal budget Feed intake – retention in products and animal biomass = excretion | CAPRI team |
| 4b) Manure | Application of manure N on crops | NUTS2 | Yearly |  | Based on CAPRI fertilizer module, application rates depending on crop N requirements and N availability, crop over-fertilization factors. Data calculated at NUTS2 and disaggregated to FSU level | CAPRI team |
| 4c) Manure | Application of manure N on crops | FSU | Same as 1c) |  | Data from 4b) disaggregated to FSU level. | JRC-CAPRI |
| 5e) Biological N fixation (BNF) rates | Biological N fixation | NUTS0 |  |  | BNF as fraction of crop N uptake by crop type | CAPRI team |
| 6a) Total N deposition levels | EMEP MSC-W modelled air concentrations and depositions |  | Yearly |  |  |  |
| 7a) Crop yields | Eurostat statistics on crop production of major crop groups  | NUTS2 | Yearly (2000-2010) | Review needed | Eurostat statistics downscaled according to CAPRI to NUTS2 level.  | CAPRI team  |
| 7a) Crop yields | Crop production of major crop groups  | 1km | Yearly (2000-2010) | Review needed | Disaggregation of 7a) to FSU level using additional information on irrigation (FAO and FSS) and potential and rain-fed yield (PESETA project).  | JRC-CAPRI |
| 8) N and P contents in crops | Country-specific N and P contents for major crop groups / Eurostat | EU | Static  |  | CAPRI look-up table of crop N contents.Calculation with crop yield data. | na |

# Processing Workflow for spatial nutrient accounts

Based on these input data, the workflow for spatial nutrient accounts consists of 12 steps in total, several of which are broken down into sub-steps. They describe the data processing steps required for producing interim data layers and the final spatial nutrient accounts.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Step | Input datasets | Processing | Result |
|  | **Create a spatial layer of cropland and grassland farming across Europe (focus on EU-28, minus Croatia)** | * 1a) Crop area predictions from the LAPM (Land Area Prediction Model) at FSU (Homogeneous Spatial Unit) level.
* 1b) Farm Structure Survey crop area at 10 x 10 km grid, gap-filled, for the year 2010 (other years not (yet?) available)
* 1c) CAPRI crop area at NUTS2 level for time series 2000 – CAPRI base year; now-casting is possible for later years
 | Constraining 1a) results with 1b) to derive priors as input to constrain to 1c). | A) Crop and grassland area at FSU level for time series (2000 – current year-2).  |
|  | **Create spatial layer on mineral N fertilizer application** | * 2a) Country statistics on the use and application of mineral fertilizer by major crops for time series
* 2b) Mineral fertilizer application by crop at NUTS2 level from CAPRI for time series based on 2a)
* Crop and grassland area at FSU level (Result A from step 1) for time series
* Crop yield at FSU level (Result H from step 8) for time series
* 2c) Crop nutrient requirements based on CAPRI look-up table of crop N contents
 | Disaggregate 2b) to the FSU level based on crop distribution, and crop N requirements (taking into account other sources of N as e.g. manure from H). | B) Mineral N application to crops and grassland area at FSU level for time series (2000 – current year-2). |
|  | **Create spatial layer for livestock distribution as preparation for step 4** | * 3a) Farm Structure Survey livestock numbers at 10 x 10 km grid, gap-filled, for the year 2010 (other years not (yet?) available)
* 3b) CAPRI livestock numbers at NUTS2 level for time series
* 3c) E-PRTR database of large pig and poultry farms for the years 2007 – current year 2
 | Downscaling livestock numbers to FSU constrained by 3a) and further on by 3b). Possibly using 3c as additional information for pig and poultry. | C) Livestock numbers (distinguishing dairy cattle, other cattle, sheep + goats, pigs, poultry and other animals) at FSU level for time series (2000 – current year-2) |
|  | **Calculate nutrient excretion from livestock and create spatial layer for manure application to crops** | * 4a) Dynamic excretion rates calculated as animal budget: feed intake – retention in products and animal biomass = excretion. Combined with 3b) to calculate N excretion from livestock.
* 4b) Application of manure N on crops based on CAPRI fertilizer module. The module takes into account crop N requirements, N availability and crop over-fertilization factors. CAPRI data at NUTS2 level for time series
 | Downscaling of 4b) to the FSU level based on A) and C) | D) Manure application to crops and manure deposition by grazing animals on grassland at FSU level for time series (2000 – current year-2) |
|  | **Estimate amount of N fixed in crops** | Biological N fixation (BNF) data set; BNF is estimated as fraction of crop N uptake by crop type | Calculate N fixation from BNF, crop N requirements and crop type/yield (A and G) | E) BNF at FSU level for time series (2000 – current year-2) |
|  | **Estimate total N deposition levels on cropland and grassland from air**  |  |  |  |
|  | **Create a spatial layer of crop yields** | 7) Eurostat statistics on crop production and yield at NUTS2 level for time series, checked for consistency within CAPRICrop and grassland area at FSU level (Result A from step 1) for time series | Disaggregating crop production based on combining 7a) with A), taking additional information on irrigation, potential/rain-fed yield into account. | G) Crop yield at FSU level for time series (2000 – current year-2)  |
|  | **Estimate N contents in crops removed from the fields** | 8a) Country-specific N contents for major crop groups / Eurostat8b) Where data not available, CAPRI modelling \* | CAPRI look-up table of crop N contents.Combine with crop yield data (G) to estimate N removal at spatial level;straw and crop residues movements considered. | H) N removal with crop and grass biomass at FSU level for time series (2000 – current year-2) |

**\*Methodological note regarding N-removal with crops:**

* The CAPRI team points out that N removal concerns harvested material plus crop residues removed (as feed or bioenergy or burning or other use).
* Seeds for planting are currently not considered in the CAPRI N-balance at FSU level as input. This should ideally be changed. It is not clear whether it will be possible to work on this for the 2018 product.

\*\***Methodological note regarding denitrification:**

* Denitrification is part of the methodology proposed in the ecosystem accounting literature.
* Total soil N-surplus is differentiated into leaching and denitrification. However, the CAPRI team considers that the factual evidence that documents the denitrification process is low, data are uncertain. Therefore it is probably better to work with total surplus.

# Parameters

The disaggregated nitrogen data from CAPRI time series is produced by JRC for EU 27 (EU28 minus Croatia). The data is available for the years 2000-2012 in 2-year-steps. It includes 12 nitrogen flows relevant for the soil surface surplus of the nitrogen balances, plus agricultural activities such as the crop yields and the area of each crop and the total Utilised Agricultural Area (UAAR) of the FSU. The parameters are as listed in Table 2.

Table 2: Overview of delivered parameters of the CAPRI model

|  |  |
| --- | --- |
| Parameters | Definition |
| ATMOSD | Atmospheric N deposition (kg/ha) |
| BIOFIX | Biological N fixation (kg/ha) |
| CRESID | Crop residuals (kg/ha) |
| MANLOSSES | Manure losses from manure after application (NH3, N2O, NOX, run-off) (kg/ha) |
| MINLOSSES | Mineral fertiliser losses (NH3, N2O, NOx, runoff) (kg/ha) |
| MMSLOSSESS | Losses from manure management systems (kg/ha) |
| NMANAP | Manure input net of all surface losses. Part applied intentionally to agricultural land (kg/ha) |
| NMANGR | Manure input net of all surface losses. Part deposited by grazing animals (kg/ha) |
| NMINSL | Mineral fertilizer N input net of gaseous losses and run-off (kg/ha) |
| NRET | N Uptake (kg/ha) |
| NinSOI | N input to the soil (kg/ha) |
| SURSOI | Surplus to soil (kg/ha) |
| YILD | Crop yields (kg/ha) |
| LEVL | Cultivation of crops [1000 ha] (1000 ha) |
| LEVLLIVESTOCK | Number of animals [1000 head] or [1000000 head for poultry] |

# Accounting aggregates

Based on the parameters provided in CAPRI, different aggregates can be calculated, based on accounting requirements. Some are already included as parameters in CAPRI, such as NinSoi or Sursoi, other such as the N-input from manure and mineral fertiliser or the Gross Nitrogen Budget can be calculated by using the following formula.

**Total excretion of N in manure**

EXCRET = NMANAP + NMANGR + MANLOSSES + MMSLOSSES

**N input from manure and mineral fertilizer**, with

N input = NMANAP + NMANGRA + MANLOSSES + NMINSL + MINLOSSES+ MMSLOSSES

**N inputs to soil** (NinSOI) refers to N that 'enters the soil' with possible fates being

uptake (NRET) and surplus (SURSOI), it represents input as the farmer applies, emissions from application have yet to occur

NinSOI = BIOFIX + NMINSL + NMANAP + NMANGR + ATMOSD + CRESID

Hence, the Total N input includes NinSOI and losses from mineral fertiliser and manure applications: NinSoi + MINLOSS+MANLOSS

**Soil surface surplus** all gaseous emissions from manure and mineral fertilizer as well as runoff already subtracted. It equals N-leaching and denitrification (N2)

SURSOI = NinSOI – NRET

**Gross Nitrogen Budget**

GNB = SURSOI + MANLOSSES + MINLOSSES + MMSLOSSES.

The aggregates are calculated per FSU and can be mapped using the FSU reference layer.

**Geo-spatial processing**

The CAPRI model provides results at the level of Farm Structure Soil Units (FSU), which is a polygon dataset. This means, each value derived from the CAPRI model is representative for the entire area of one FSU polygon (which range in size from 1 km2 to 100 km2 (with an average size of 22 km²), depending on the environmental and agronomic diversity in the European regions).

In order to combine the CAPRI data with the HNV dataset the FSU polygons have to be converted to a raster dataset with a spatial resolution of 100 x 100 m. Furthermore this means that all pixels inside a FSU will be assigned the same value (as the FSUs are designed to represent areas of fairly homogenous agricultural land use).

The information of the CAPRI dataset is classified into three classes of intensity before the conversion:

|  |  |  |
| --- | --- | --- |
| **Total N-Input** | **Level of intensity** | **Intensity Code** |
| 0 – 50 kg | Low intensity | 1 |
| 50 - 100 | Medium intensity | 2 |
| > 100 kg/ha | High intensity | 3 |

The result of this conversion is a raster dataset, in which all pixels within a FSU are assigned to values of either (1) low, (2) medium or (3) high intensity, depending on the overall characteristics of each FSU. This is illustrated in Figure 1:

**Figure 1: Outcome of assigning N-intensity classes at FSU level**

# Spatial distribution of livestock numbers for HNV farmland assessment

Alongside nutrient input intensity, the spatial distribution of livestock density is a crucial farming intensity parameter that is used for the updated assessment of the High-Nature Farmland indicator.

Livestock density data are extracted as well from the CAPRI database. For this purpose, the number of heads of livestock groups differentiated for grazing and non-grazing animals where modelled, based on grazing-nongrazing share taken from LULUCF country reporting. The area for grazing animals is based on shares of various Corine Land Cover Classes that have been estimated to be suitable for grazing (see Table in the Annex – Proposal for CLC classes suitable for grazing). The area for non-grazing animals is UAAR from the CAPRI database. Three livestock categories are differentiated: Dairy Cattle, Non-Dairy Cattle and Sheep and Goats.

The livestock density LU/ha is calculated first separately for each livestock category, applying the following conversion factors:

* Dairy cattle 1.00
* Non-Dairy cattle 0.74
* Sheep & Goat 0.10

The livestock density is then aggregated both for all grazing livestock and non-grazing livestock and then combined to provide a total livestock density. This operates in 3 steps:

1. Calculation of livestock unit density for non-grazing livestock on the agricultural base area provided by the CAPRI model (i.e. FSS based Utilised Agricultural Area[[1]](#footnote-1))
2. Calculation of livestock unit density for grazing livestock on the agricultural base area developed from the likely area suitable for grazing by livestock, as derived from expert estimates on the likely use of CLC classes for grazing (see Table 3 in the Annex).
3. Sum of livestock unit densities from grazing and non-grazing livestock at the level of FSUs.

The resulting map in Figure 2 shows hotspots of livestock density in the Netherlands, north-western Germany, south-eastern Germany and the Italian Po Valley.

**Figure 1: Livestock density estimated based on CAPRI data & CLC grazing area**

*Note: this only includes ovine and bovine livestock; if pigs and poultry were added the average livestock density would be considerably higher in many regions.*

The following observations should be taken for further review of the input data:

* In general, grazing livestock has very low livestock density all over Europe
* According to LULUCF estimates dairy cattle are estimated not to graze in Spain, Germany and Scotland – this is likely not to be in line with actual agricultural practice
* The expert assessment of the likely use of CLC classes for grazing is undergoing review and needs to be further improved, both with regard to the geographic variation of the rules applied as well as the estimated weighting factors for likely share of actually grazed area per CLC class.

# Annex – Proposal for CLC classes suitable for grazing

| **LEVEL 1** | **LEVEL 2** |  | **LEVEL 3** | **Additional comments** |
| --- | --- | --- | --- | --- |
| 1. Artificial Surface | 1.1 Urban fabric | 1 | 1.1.1 Continuous urban fabric |  |
|  |  | 2 | 1.1.2 Discontinuous urban fabric |  |
|  | 1.2 Industrial, Commercial and  | 3 | 1.2.1 Industrial or commercial units |  |
|  |  transport units | 4 | 1.2.2 Road and rail networks and associated land |  |
|  |  | 5 | 1.2.3 Port Areas |  |
|  |  | 6 | 1.2.4 Airports |  |
|  | 1.3 Mines, dumps and construction  | 7 | 1.3.1 Mineral extraction sites |  |
|  |  sites | 8 | 1.3.2 Dump sites |  |
|  |  | 9 | 1.3.3 Construction sites |  |
|  | 1.4 Artificial non-agricultural vegetated areas | 10 | 1.4.1 Green urban areas |  |
|  |  | 11 | 1.4.2 Sport and leisure facilities |  |
| 2. Agricultural areas | 2.1 Arable land | 12 | 2.1.1 Non-irrigated arable land \* | \* (50 %) for cattle25 % of 211 for sheep + goat  |
|  |  | 13 | 2.1.2 Permanently irrigated land \* | \* (50 %) for cattle25 % of 211 for sheep + goat  |
|  |  | 14 | 2.1.3 Rice fields |  |
|  | 2.2 Permanent crops | 15 | 2.2.1 Vineyards |  |
|  |  | 16 | 2.2.2 Fruit trees and berry plantations | *Only some grazing in traditional orchards in Atlantic + Continental zone, hence not included..* |
|  |  | 17 | 2.2.3 Olive groves \* | Sheep + goats only |
|  | 2.3 Pastures | 18 | 2.3.1 Pastures \*\*\* |  |
|  | 2.4 Heterogeneous agricultural areas | 19 | 2.4.1 Annual crops associated with permanent crops |  |
|  |  | 20 | 2.4.2 Complex cultivation patterns \* |  |
|  |  | 21 | 2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation \*\* |  |
|  |  | 22 | 2.4.4 Agro-forestry areas \*\* |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 3. Forest and semi-natural areas | 3.1 Forests | 23 | 3.1.1 Broad-leaved forest |  |
|  |  | 24 | 3.1.2 Coniferous forest |  |
|  |  | 25 | 3.1.3 Mixed forest |  |
|  | 3.2 Scrub and/or herbaceous  | 26 | 3.2.1 Natural grassland \*\*\* |  |
|  |  vegetation associations | 27 | 3.2.2 Moors and heathland \*\* | Only one \* in B, NL, D, DK, AT, CZ, SK, HU, LI, LV, EE, S, FI, PL, LUX, N\* (25 %) for cattle for all countries |
|  |  | 28 | 3.2.3 Sclerophyllous vegetation \*\* | \* (25 %) for cattle |
|  |  | 29 | 3.2.4 Transitional woodland-scrub \* | Only on British Isles and in Scandinavia |
|  | 3.3 Open spaces with little or no vegetation | 30 | 3.3.1 Beaches, dunes, sands |  |
|  |   | 31 | 3.3.2 Bare rocks |  |
|  |  | 32 | 3.3.3 Sparsely vegetated areas \* |  |
|  |  | 33 | 3.3.4 Burnt areas |  |
|  |  | 34 | 3.3.5 Glaciers and perpetual snow |  |
| **LEVEL 1** | **LEVEL 2** |  | **LEVEL 3** |  |
| 4. Wetlands | 4.1 Inland wetlands | 35 | 4.1.1 Inland marshes \*\* |  |
|  |  | 36 | 4.1.2 Peat bogs \* | Sheep only (and thus goats..) |
|  | 4.2 Coastal Wetlands | 37 | 4.2.1 Salt marshes \*\* | *.* |
|  |  | 38 | 4.2.2 Salines |  |
|  |  | 39 | 4.2.3 Intertidal flats |  |
| 5. Water bodies | 5.1 Continental waters | 40 | 5.1.1 Water courses |  |
|  |  | 41 | 5.1.2 Water bodies |  |
|  | 5.2 Marine waters | 42 | 5.2.1 Coastal lagoons |  |
|  |  | 43 | 5.2.2 Estuaries |  |
|  |  | 44 | 5.2.3 Sea and ocean |  |
|  |
| ***Highlighted classes are those related to HNV farmland*** |

Classes marked with \* are considered to be used for grazing, at least by certain types of livestock and certain regions. It is proposed to use 100 % of the surface of those classes marked with \*\*\*, 50 % for those with \*\* and 25% for those marked by \*.

1. The Utilized Agricultural Area (UAA) refers to the land used for farming; it includes arable land, permanent grassland, permanent crops and also kitchen gardens. [↑](#footnote-ref-1)