Modelling the gross nitrogen balance in Europe with CAPRI:

from country-scale to the pixel

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Why regionalisation of the GNB?

→ **COM(2006)508**

- The recent developments of the CAP call for better monitoring of changes in agricultural production systems / land use patterns / effects on the environment at regional level
- A coherent system of AEIs must be able to: reflect the regional diversity of agricultural production systems and natural conditions and to capture the main positive and negative effects of agriculture on the environment

→ **Rural Development Program**

- Data needed at national / regional level

→ **Nitrate Directive**

- Data needed at NUTS2 / Nitrate Vulnerable Zones / Watershed

→ **Water Framework Directive**

- Data needed at river basin / district level

→ **Designing, monitoring, evaluation of agri-environmental measures**

Problems in regionalisation

→ **(1) Many data are not available at regional level**

- e.g. inorganic fertilsier: statistical data on regional level available for very few countries

→ **(2) Coefficients are not sufficiently adapted to local conditions (soil, climate, farming systems, …)**

- e.g. manure excretion: need to reflect feeding systems, stable conditions, feeding measures

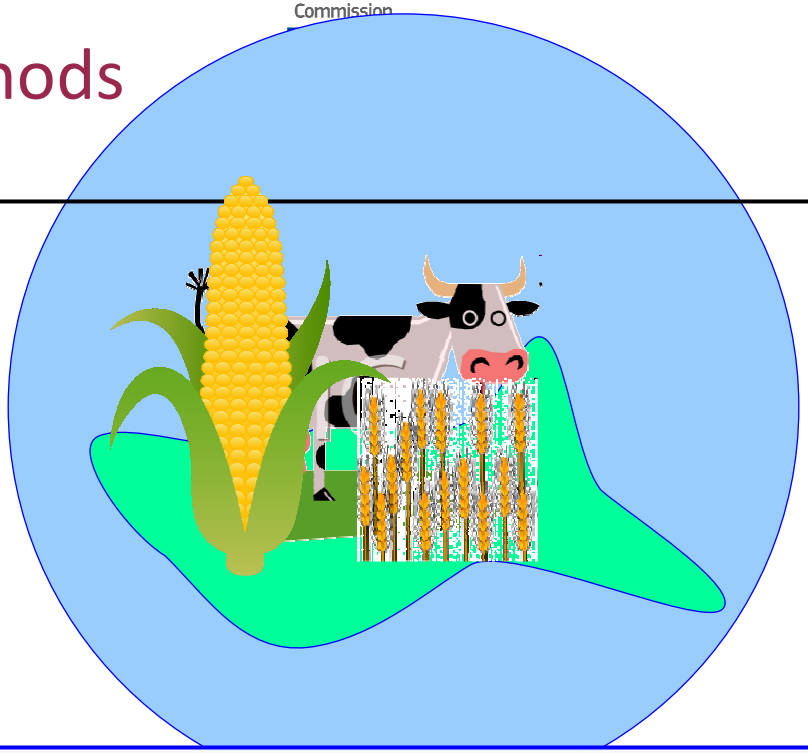
Eurostat conclusion TAPAS projects:

"methodology can be used at the regional level, but is not fully appropriate for this purpose"

Source: WG-meeting eurostat nov 2009

Spatialisation methods

National scale:	Regional scale:
- Mineral fertiliser	?? -
- Animal numbers	Animal numbers -
- N-excretion	?? -
- Atmospheric Deposition	Atmospheric - Deposition -
- Biological N-fixation	?? -
- Crop production	Crop production -



Environmental conditions – productivity – N-excretion – mineral fertiliser application are linked!

Requires additional data: economic accounts, feeding systems, …

Constraints by national totals and internal consistency!!

Proposed concept: the CAPRI model (i)

→ **Established links to eurostat databases**

- checking on data gaps and inconsistencies
- CoCo data base: complete and consistent data at national level

→ **Harmonised approach for all countries**

- relatively low cost to implement
- relatively low cost when update required

→ **Tracking of nitrogen through agricultural systems**

- N-excretion calculated with 'animal balance'
- Market, animal, farm, and soil N-balances calculated and closed

Proposed concept: the CAPRI model (ii)

→ **Dedicated module to regionalise the CoCo database to NUTS2**

- additional data sources (REGIO, FSS, FADN, expert data …)
- state-of-the-art econometric methods for regionalisation
- CAPREG maintains consistency with data at national level
- includes regionalised allocation of farm inputs
  (N application of mineral fertiliser and manure by crop type, feed, …)
- consistent accounting of GHG and Nr-emissions with accepted methodologies (IPCC, GAINS)

→ **Dedicated module to spatialise the CAPREG database to the grid (1 km x 1 km)**

- share of land uses by spatial unit based on logit-models, calibrated with LUCAS
- farm input, GHG and Nr fluxes, N-budgets disaggregated into spatial units
- CAPRI-SPAT is used also for

CAPRI caveats

→ **CAPRI model requires updating**

- update coefficients according to GNB requirements (e.g. crop-coefficients)
- review methodologies according to GNB decisions
- incorporate new data (grassland production, biological fixation, manure management systems, …)
- develop 'interface' to AEI reporting

→ **National GNB calculated with CAPRI will not be identical to national GNB calculated by countries**

- outlier removals, gap fillings etc. overwrite raw statistical data
- concept not identical, e.g. animal balance will not be replace with national N-excretion coefficients
- need for close cooperation with country-experts to understand and – if possible – eliminate sources of differences

Differences between CAPRI and national methods?

→ **Comparability of results across countries**

- Data quality similar over countries
- Harmonized methodological approach

→ **Regionalisation is expensive**

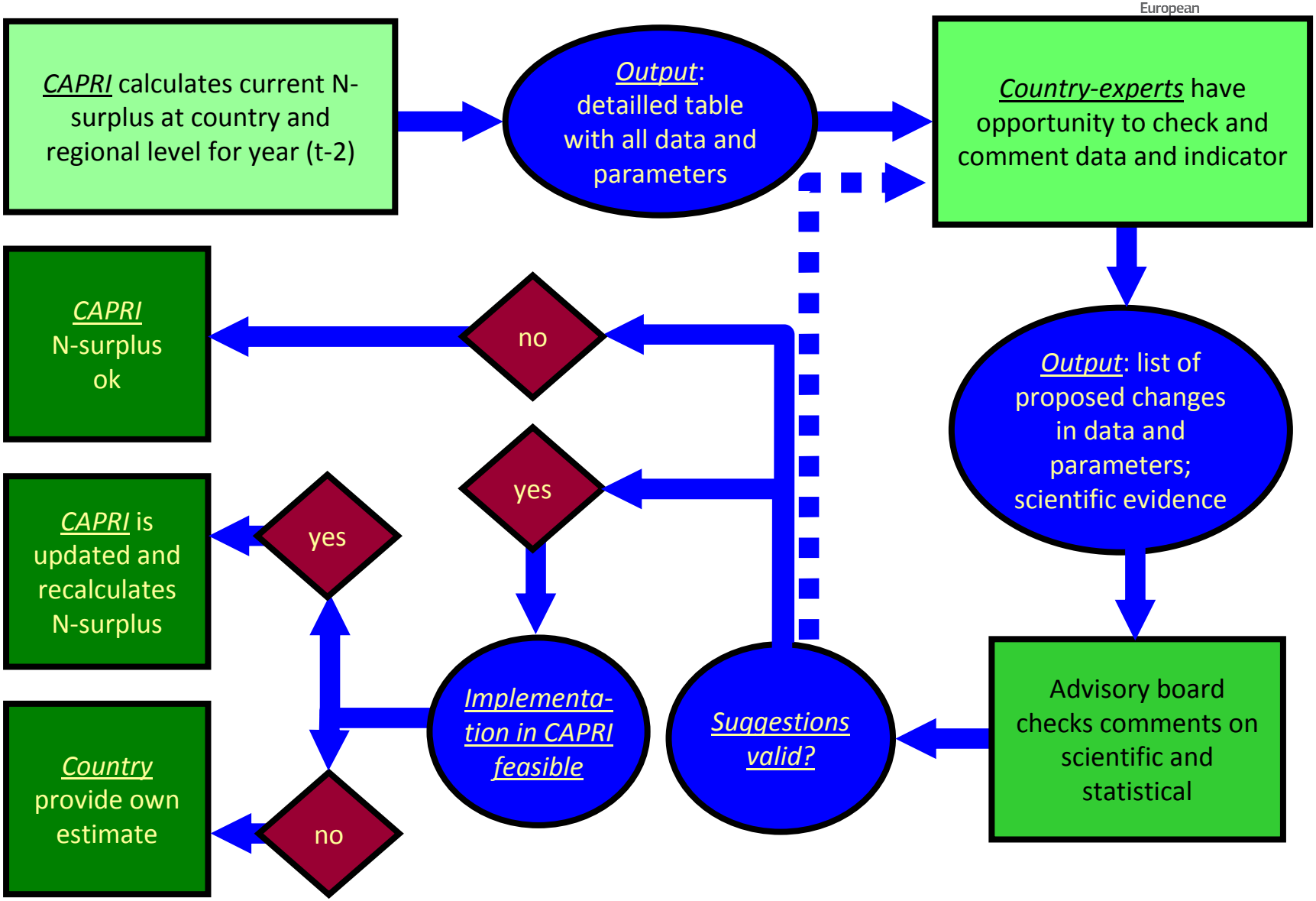
- "One model for all" cost-efficient solution
- Investment per country shifts from development of spatialisation method to checking CAPRI results *at national scale* and *where regional data are available*.

→ **Slightly different data sources** (national statistics vs. CoCo/CAPREG) **and slightly differenct concepts** (e.g. national excretion coefficient vs. animal balance)

- Opportunity for identifying problems in data
- Additional constraints to realistic figures

Some countries would be able to provide results at a higher resolution/detail
Other countries would not be able to provide results at the same resolution/detail

Possible workflow



What could this imply?

→ **Each country nominates one country-expert to review CAPRI results at NUTS2. The expert provides an assessment of the results to eurostat, indicating**

- major differences between CAPRI results and country-specific data
- an analysis of possible sources of the discrepancy
- a suggestion for aligning CAPRI data with country-specific data

→ **eurostat/jrc set up an advisory board which evaluates the findings**

- scientific validity of CAPRI and country-specific data
- priority list for working on discrepancies
- pilot projects for a few countries?

→ **"at the end of the day" two situations**

- (1) satisfying match between CAPRI and country-specific data
- (2) differences cannot be consolidated: will be flagged & accompanied with meta-information

thank you

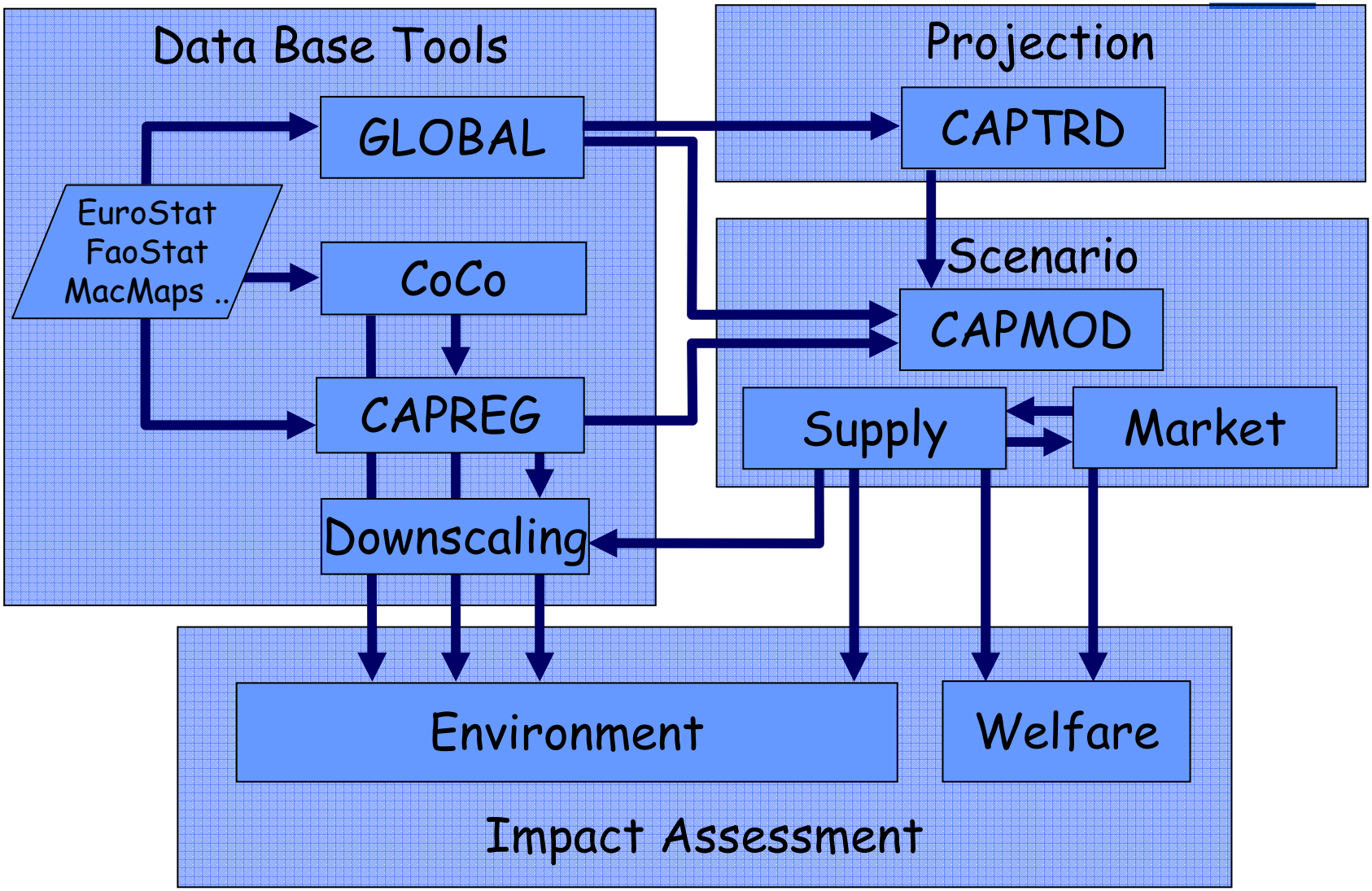
CAPRI-details

- → **The CAPRI model**
- → **Database tools in CAPRI**
- → **Regionalisation**
- → **Nitrogen Budgets in CAPRI**
- → **Data sources**
- → **Downscaling**

The CAPRI model

capri details

European Commission



What is CAPRI ?

→ **Common Agricultural Policy Regionalized Impact for policy impact assessment**

→ **"Bio-economic model", mainly EU financed (from 1995)**

→ **"multi-purpose", allows to analyze**

- Market policies (administrative prices/tariffs/preferential agreements)
- Premium systems/quotas/set-aside at regional level
- Environmental policies (standards/market solutions)
- Changes in exogenous drivers (population/inflation/exchange rates/consumption behavior/technical progress)

→ **Regarding**

- Supply/demand/trade flows - Hectares/herd size/yields/input use
- Producer & consumer prices, income indicators - Welfare effects including budget of the CAP
- Environmental indicators

→ **Open source, maintained by European network including JRC institutes**

Source: Britz et al. 2008 CAPRI documentation

Data base tools in CAPRI

Four "applications"

- → **Global: market balances, land use, trade flows, tariffs, prices, GHG inventories**
- → **COCO: Member State level: market balances, land use, herds, economic accounts, producer and consumer prices**
- → **CAPREG: regional level, input distribution; also farm type groups (specialization x economic size)**
- → **CAPRI-SPAT: 1x1 km grid cell clusters**

- → **Code is realized in GAMS**
- → **Application of Bayesian estimators to ensure completeness and consistency**

European Commission

National data base “CoCo”

→ **Acronym means “Complete and Consistent”**

→ **Builds up time series from 1985-2008 (currently) for EU27, Norway and Western Balkans and Turkey for about 50 activities and products**

→ **Main input source is Eurostat: area statistics, farm and market balances, Economic Accounts for Agriculture, Agricultural prices, household surveys …**

→ **Complemented by FAOSTAT and national statistical year books, especially for Candidate Countries**

→ **Uses constrained estimation techniques to remove data error and fill gaps, statistical based outlier detection plus manual checks**

→ **Handled by teams in Bonn and The Hague**

CoCo generates closed balances

→ **Closed physical balances**

- Crop production = yields * area
- Fat and protein balances for dairy products

→ **Closed market balances for crops**

- Total supply + import = total demand + export + stock change
- Linkage to secondary products (cakes, oils, by-products from milling …)

→ **Closed animal balances:**

- Animal herds, slaughtered heads, live imports and exports; Stock changes and stock levels link market balances over time; inter-annual herd flow model for animals
- Animal products: market balances for meat, young animals, dairy products

→ **Output values from the Economic Accounts are linked to physical output**

Permanent and temporal grass lands

Key data:

- → **Major part of land use**
- → **Key source of energy / protein for ruminants**
- → **Important part of N crop nutrient requirements and sink especially for organic N**

Suspicious series already for acreages (e.g. statistical breaks)

Particularly critical part are yields: data series are incomplete, differences between countries often implausible

Currently all yields replaced by expert assessment

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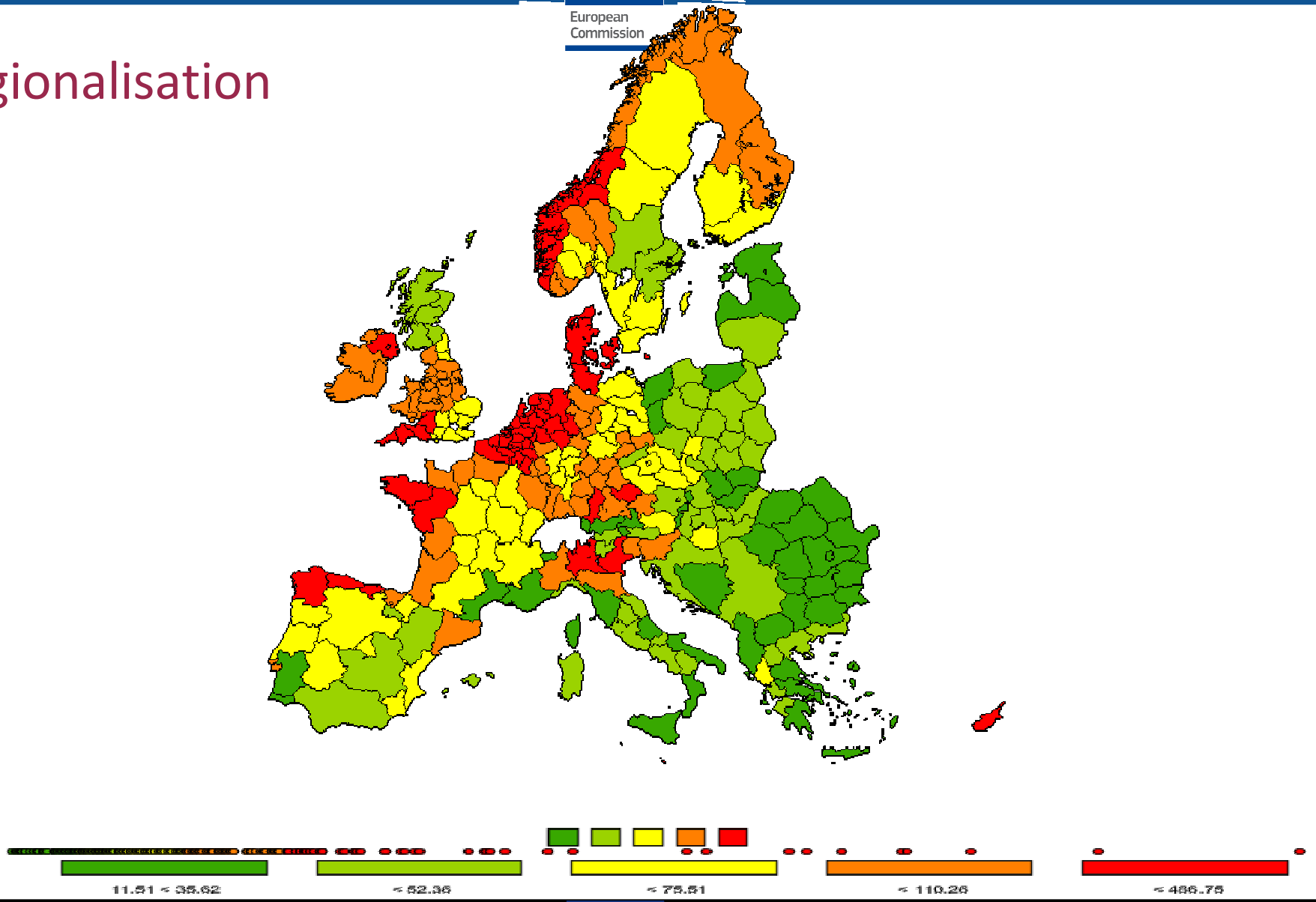
Regionalisation



Regional data "CAPREG"

→ **Introduces input allocation and regional dimension**

→ **Takes data at Member State level (CoCo results) as fix and given**

Regional statistics

→ **Main input sources:**

- REGIO domain from Eurostat (crop yields, crop areas, herd sizes)
- Complemented by FSS
- Data on CAP from DG-AGRI
- Engineering functions, results from econometric estimation (based on FADN) for input/feed/fertilizer allocation

→ **Land use**
→ **Crop production - harvested areas, production and yields**
→ **Animal production - livestock numbers**
→ **Cows's milk collection - deliveries to dairies, % fat content**
→ **Agricultural accounts on regional level**
→ **Structure of agricultural holdings**
→ **Labour force of agricultural holdings**

→ **Uses constrained estimation techniques to determine input allocation, fertilizer and feed distribution**

Source: Britz et al. 2008 CAPRI documentation

European Commission

Gap filling and constraints

CoCo		REGIO
Wheat	⟷	Wheat
Maize	⟷	Maize
Barley	⟷	Barley
Rice	⟷	Rice
Rye	⟷	$Rye_{reg} = Other_{reg} \cdot \frac{Rye_{coco}}{Rye_{coco} + Oats_{coco} + Ocer_{coco}}$
Oats	⟷	$Oats_{reg} = Other_{reg} \cdot \frac{Oats_{coco}}{Rye_{coco} + Oats_{coco} + Ocer_{coco}}$
Ocer	⟷	$Ocer_{reg} = Other_{reg} \cdot \frac{Ocer_{coco}}{Rye_{coco} + Oats_{coco} + Ocer_{coco}}$

$$UAA_{country} = \sum_{regions} crops$$

Source: Britz et al. 2008 CAPRI documentation

Crop-specific regional distribution of mineral fertiliser applications

→ **Minimum deviation of average national inorganic crop specific application rates for N,P,K from EFMA questionnaire data**

→ **Total inorganic N at national level must be exhausted by the regional and crop specific application rates times given regional crop areas**

→ **Based on regional crop N-requirements > regional N-supply (mineral fertiliser, manure availability, N-fixation, atmospheric deposition) and NH3 losses**

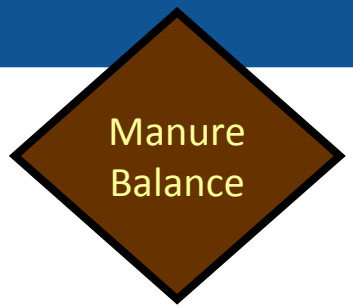
- No regional trade in manure
- No soil depletion in N

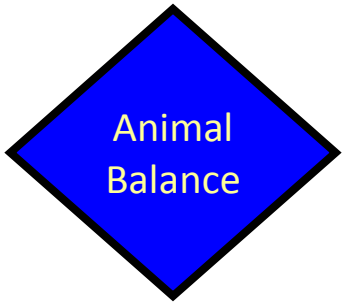
→ **Certain minimum percentages of crop needs are covered by mineral nitrogen**

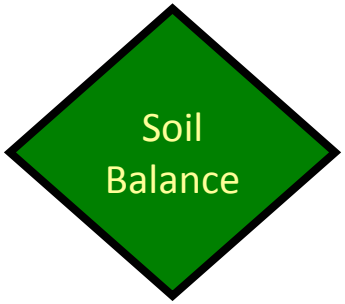
→ **Deviation of organic N share for group of crops on total N uptake of the crops from assumed typical shares**

Nitrogen balances in CAPRI

capri details







Nitrogen budgeting in CAPRI (i)
Market balance

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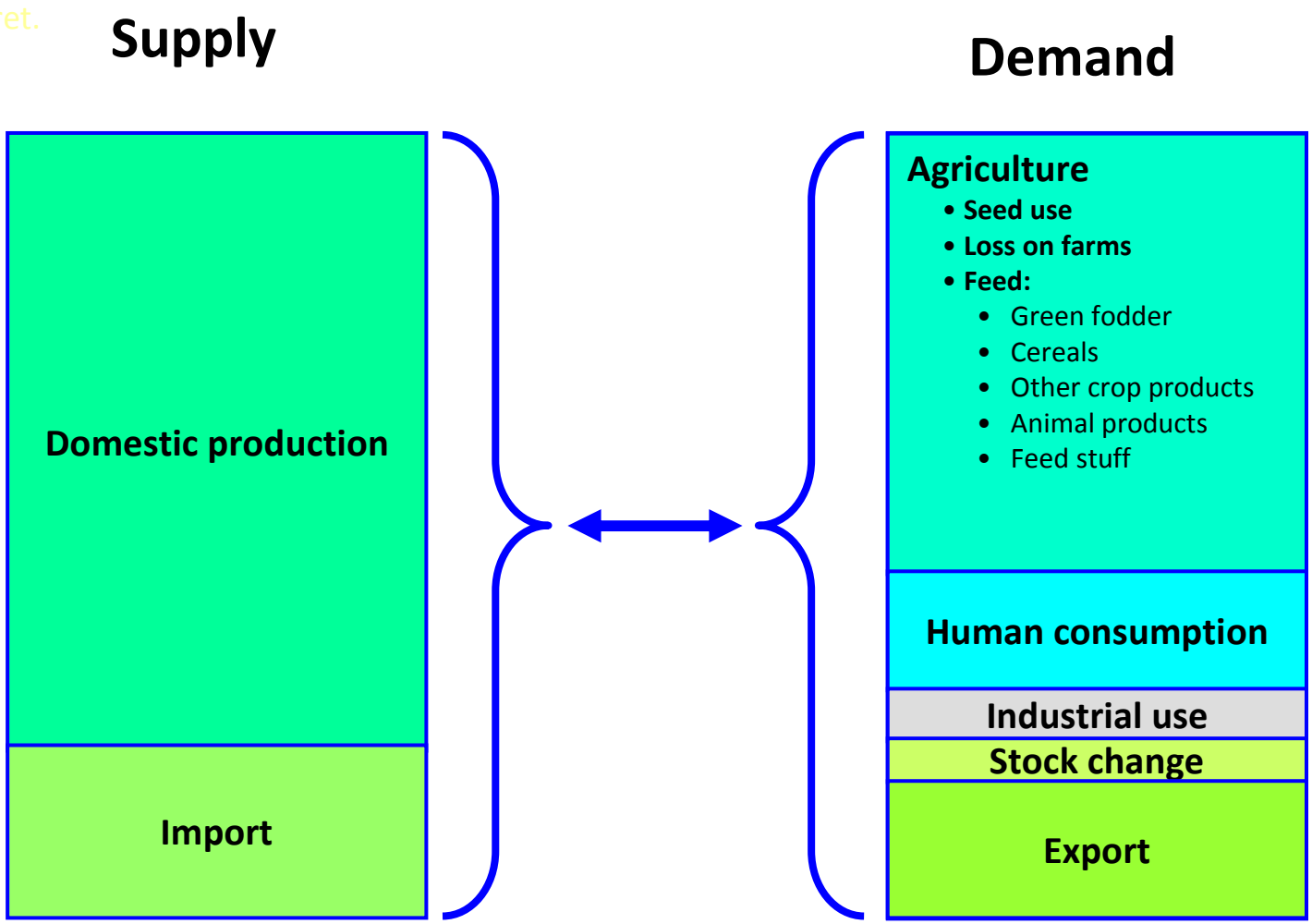
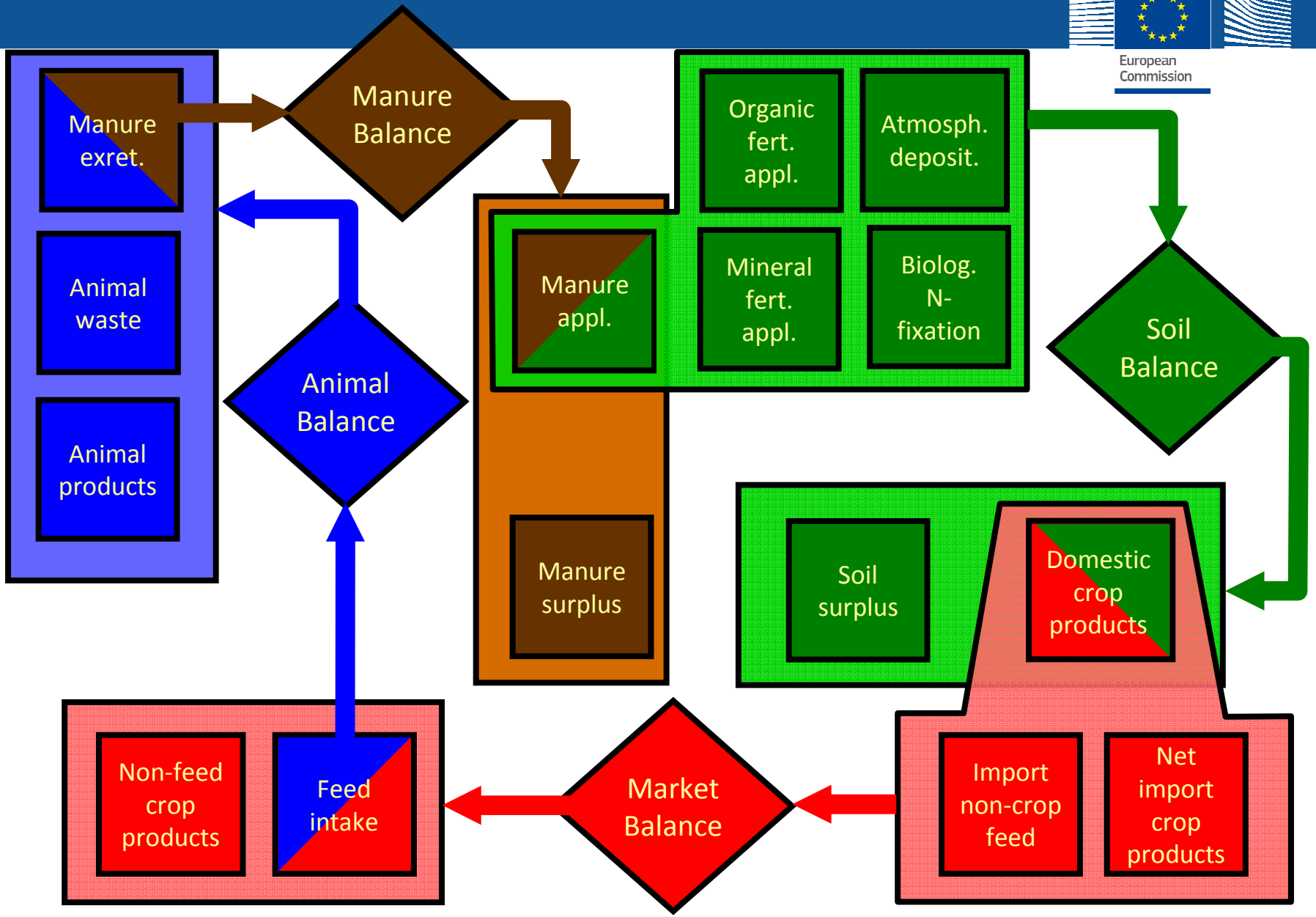
Manure exret.



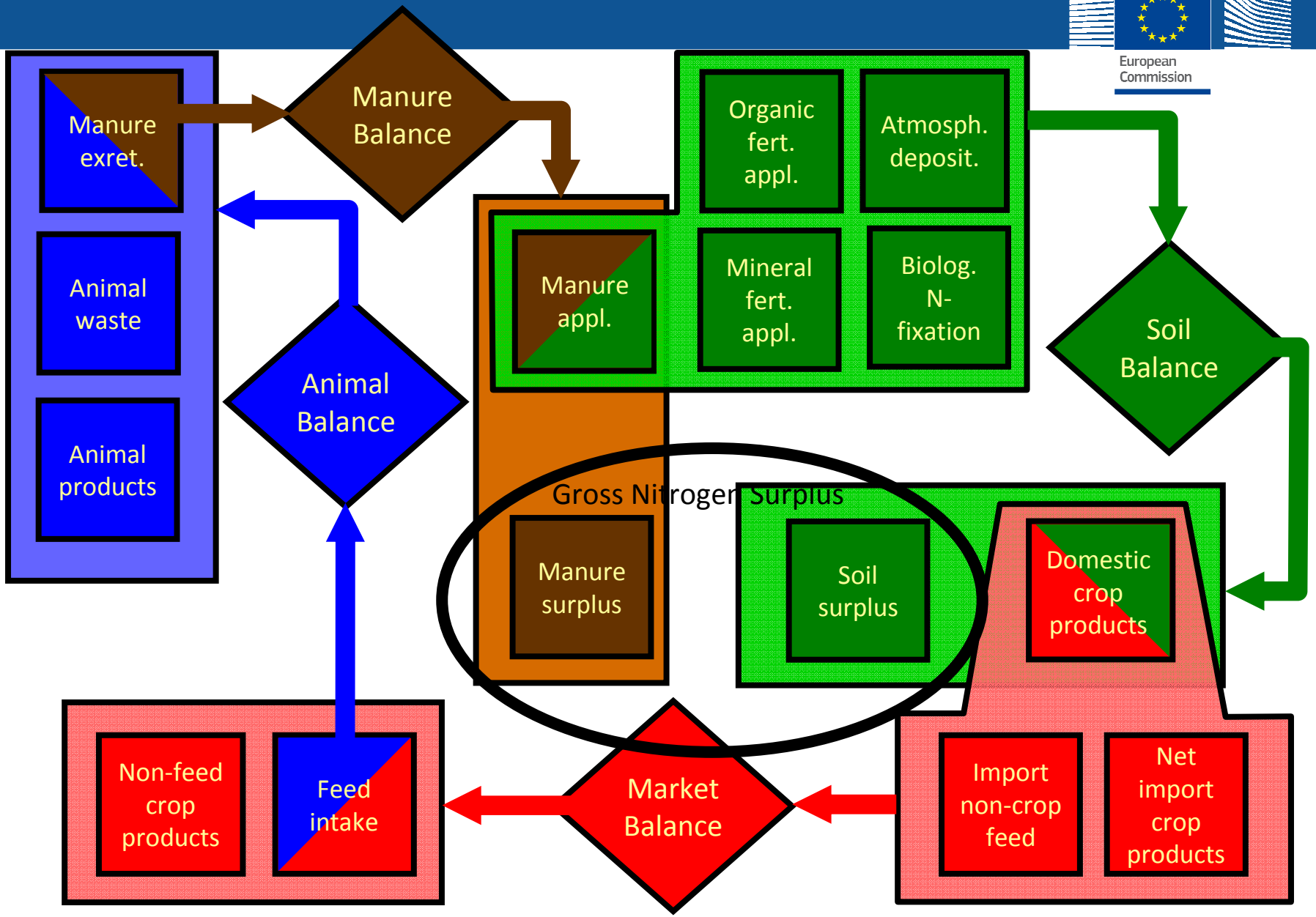
Nitrogen balances in CAPRI

capri details



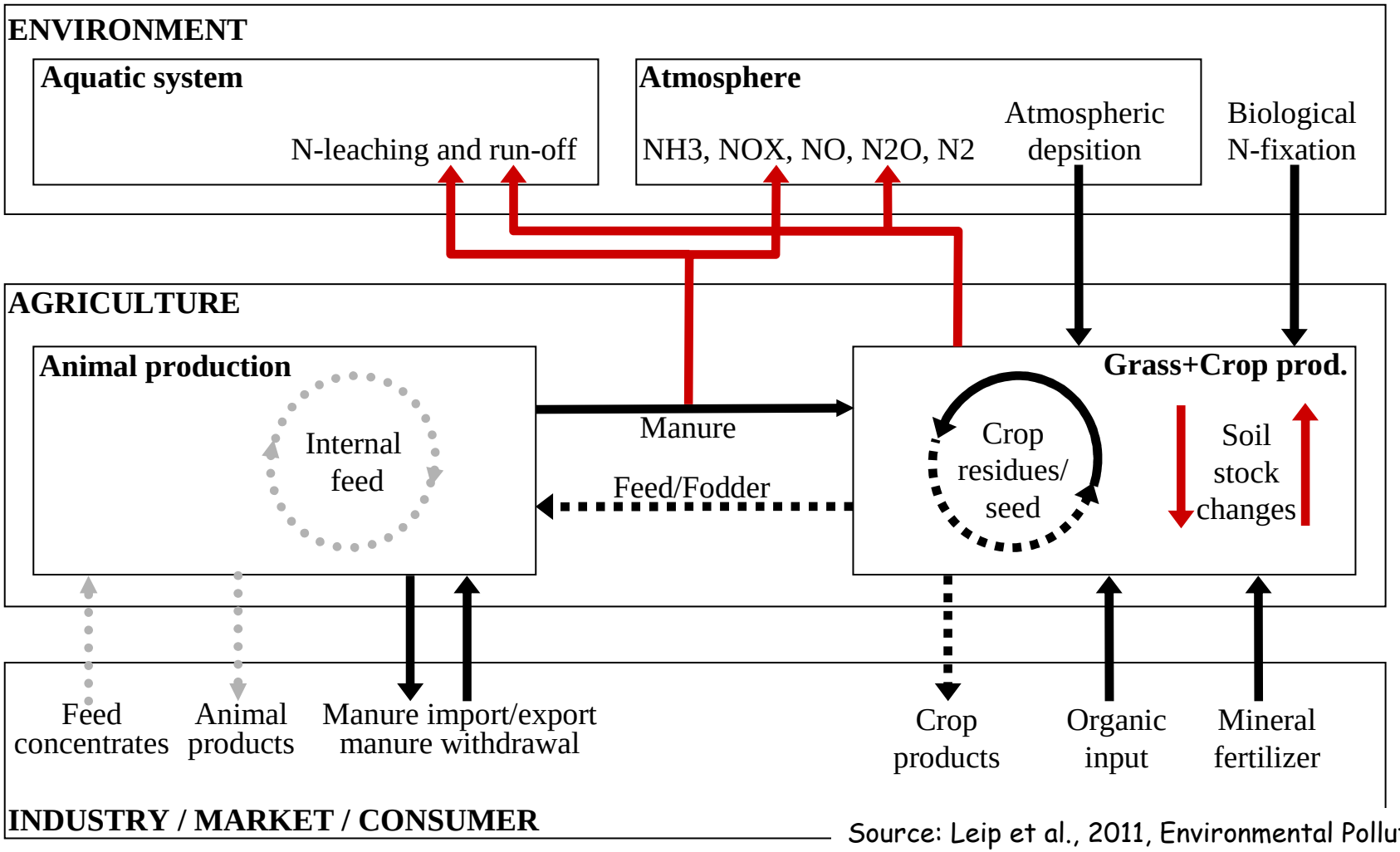
Nitrogen balances in CAPRI

capri details



Land Nitrogen Budget = Gross Nutrient Balance

capri details



Source: Leip et al., 2011, Environmental Pollution

Soil, Farm, and Land Nitrogen Surplus

capri details

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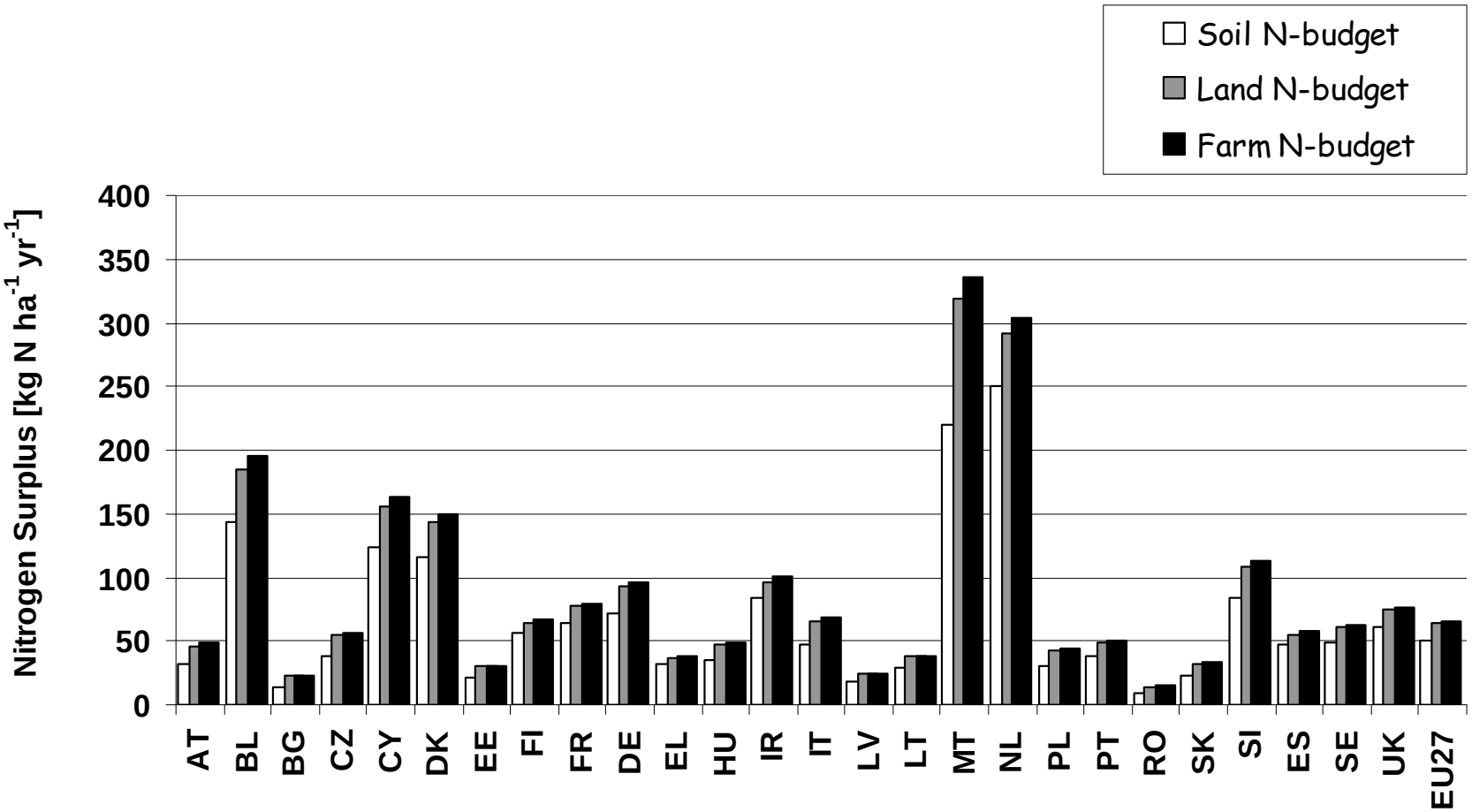
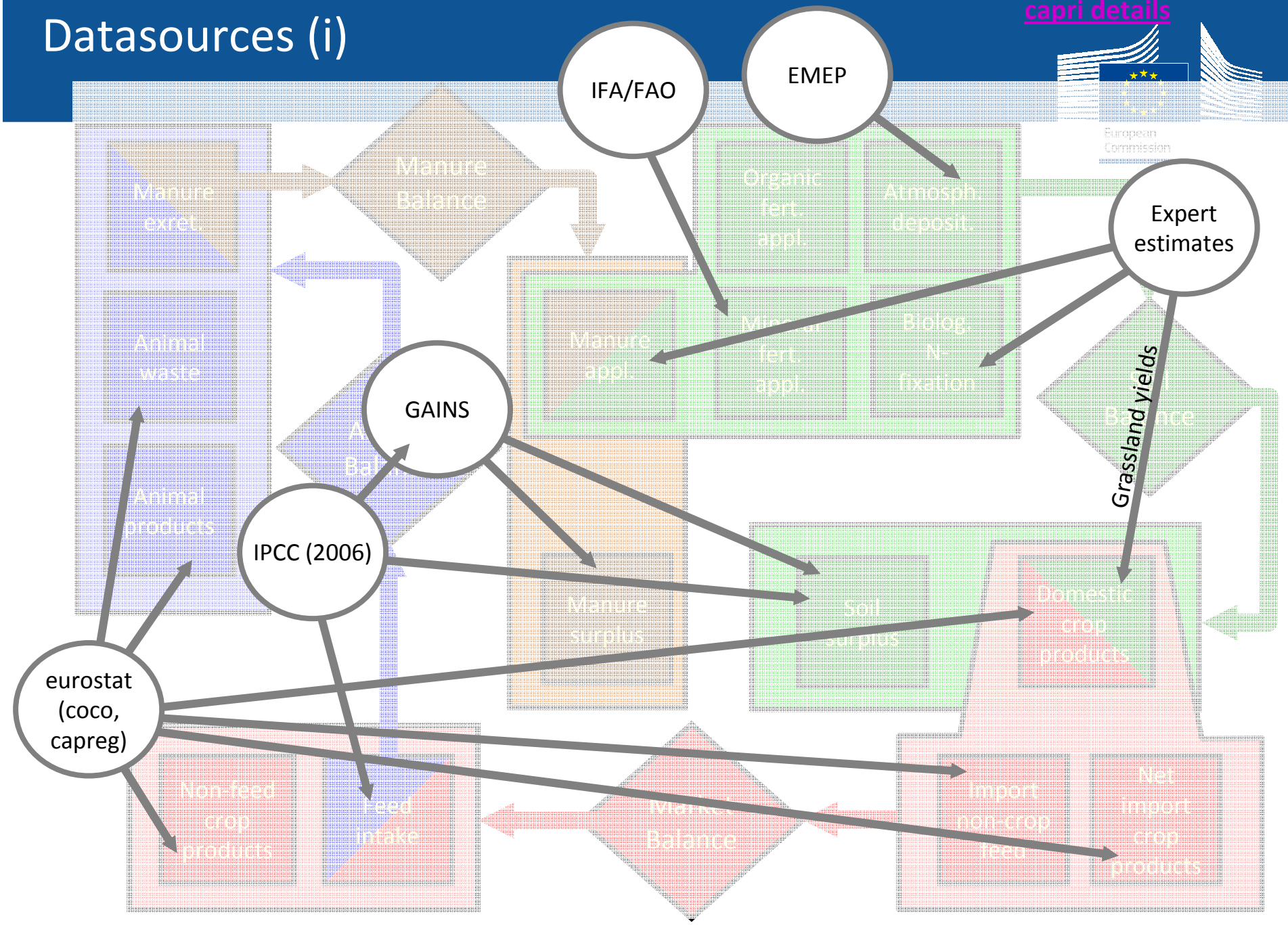


Source: Leip et al., 2011, Environmental Pollution

Datasources (i)

capri details



Datasources (ii)

Downscaling of regional data to a 1 km x 1 km grid ("HSMUs")

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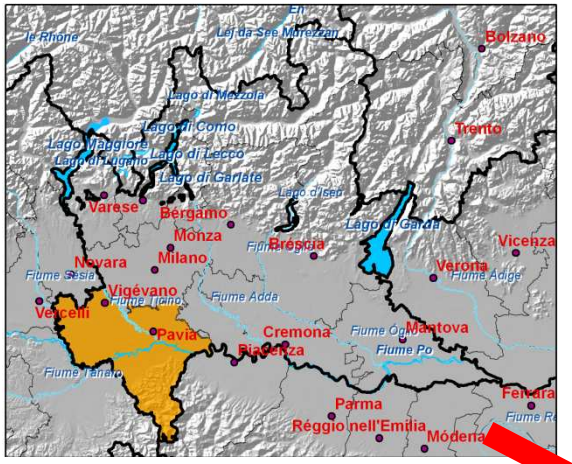
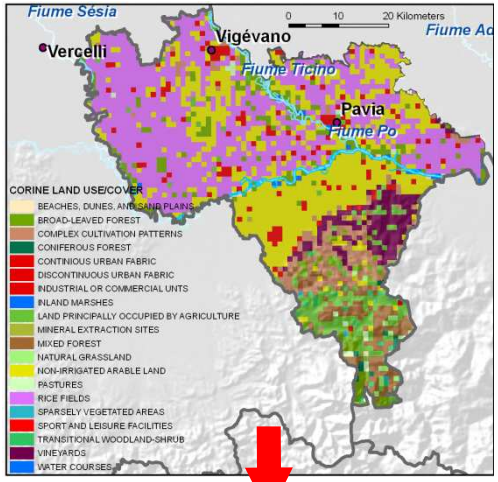
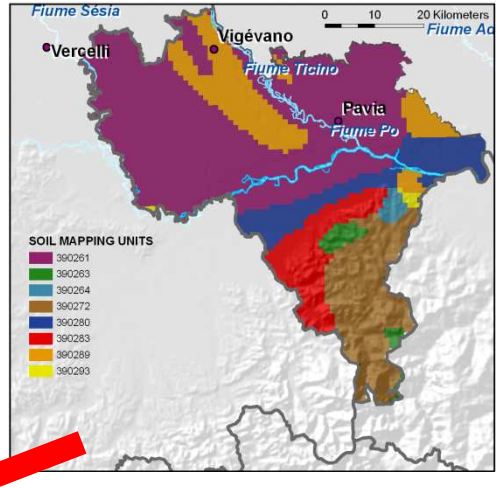
FSS NUTS REGIONS (NUTS2/3)



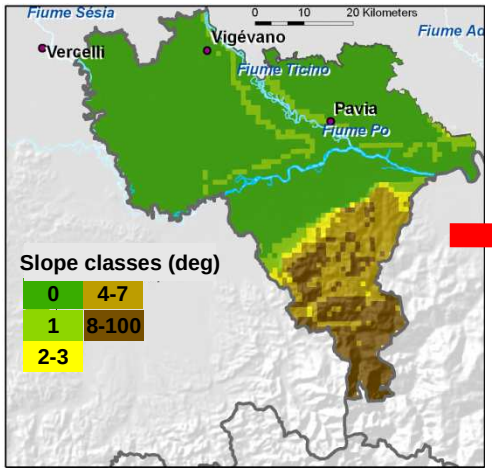
CORINE LAND USE/COVER 2000



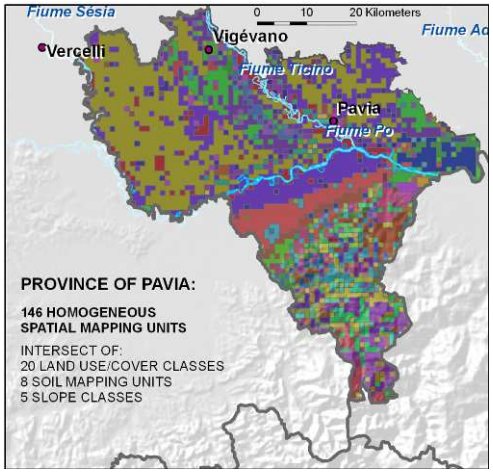
SOIL MAPPING UNITS (SMU)



SLOPE



HOMOGENEOUS MAPPING UNITS

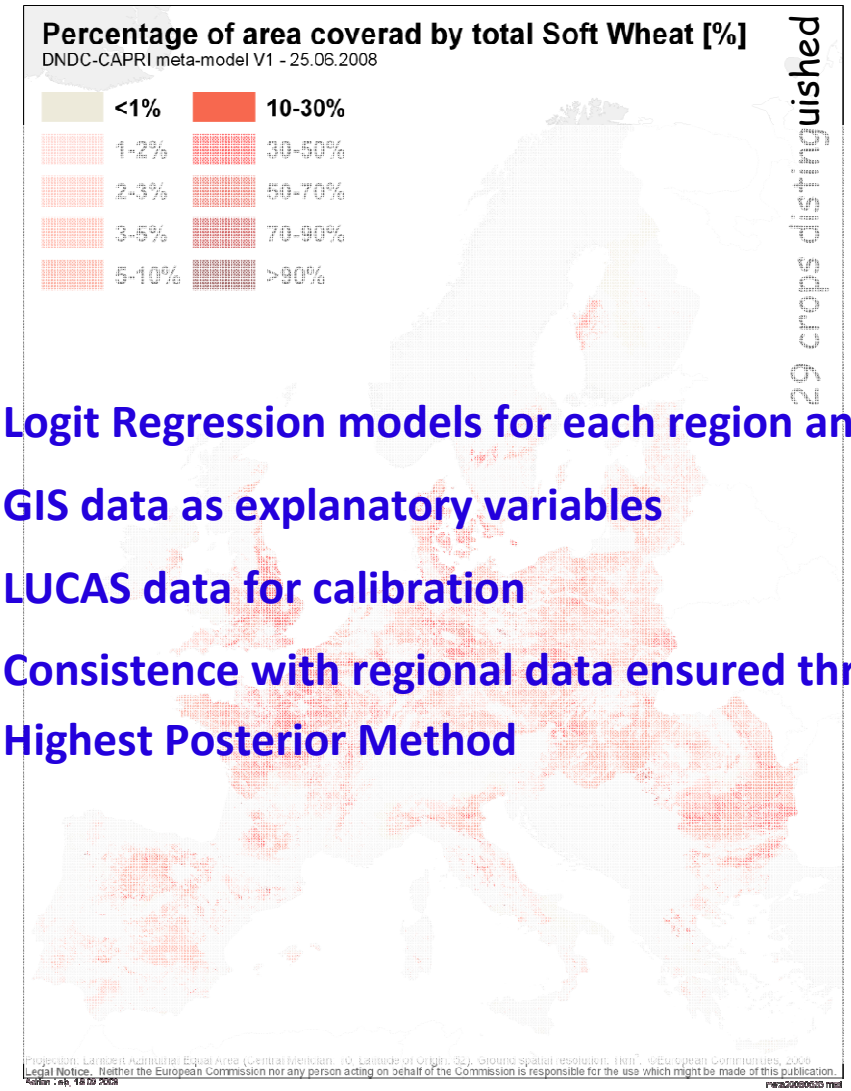


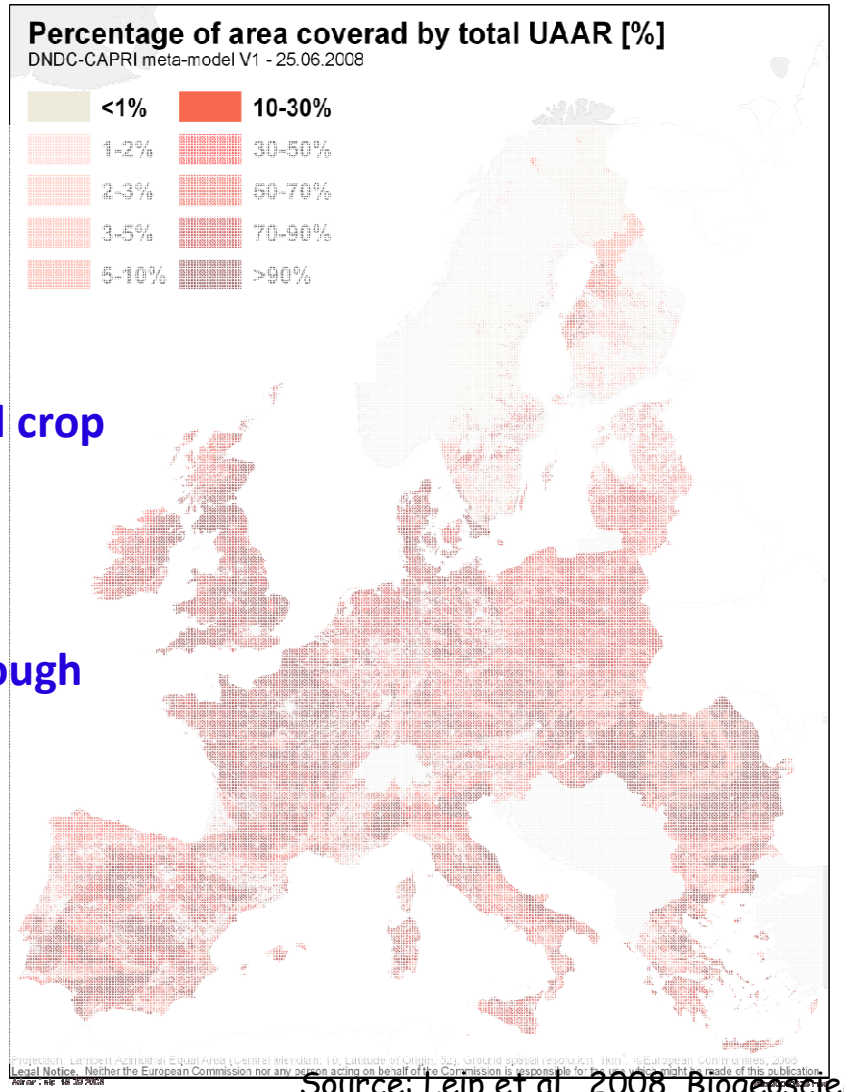
Pixel resolution: 1km by 1km
Spatial Extent: EU27
Total about 200 000 HMSUs
- ca. 206,000 HSMUs for EU-25+2
- Thereof 150,000 with agricultural land use
- average UAAR: 47%

Source: Leip et al., 2008, Biogeosciences

Agricultural Land Use Maps 2000

capri details





→ **Logit Regression models for each region and crop**

→ **GIS data as explanatory variables**

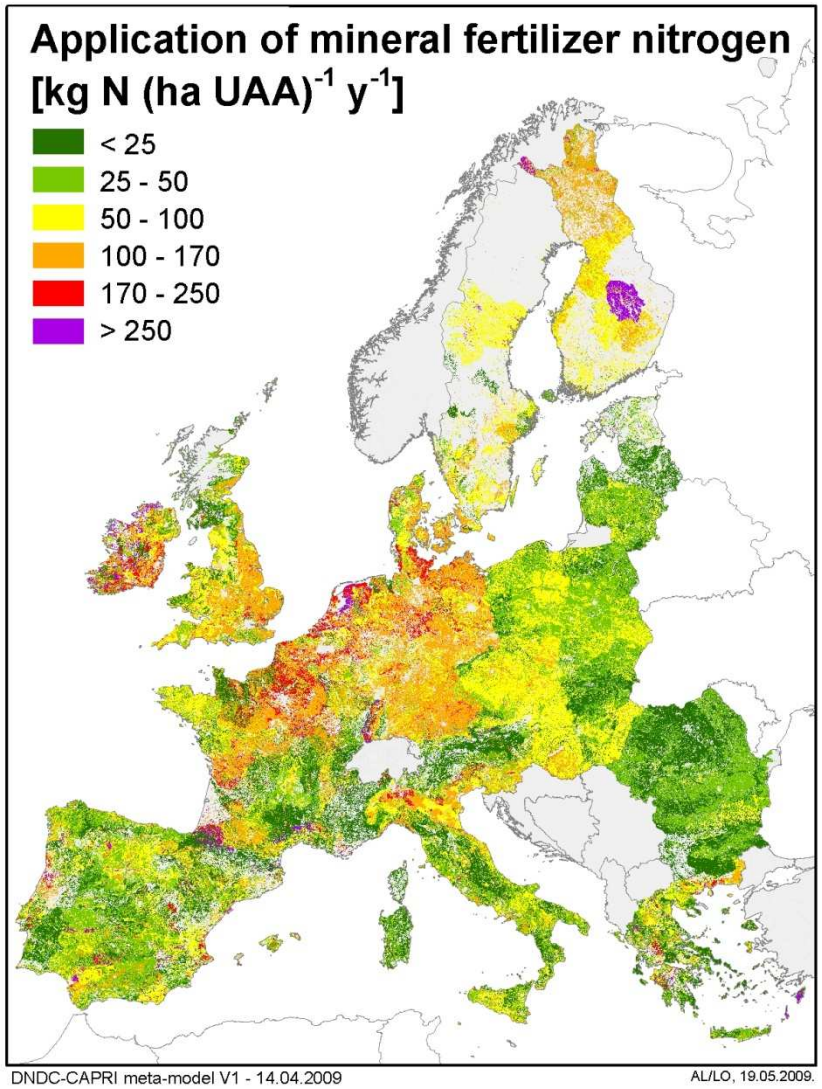
→ **LUCAS data for calibration**

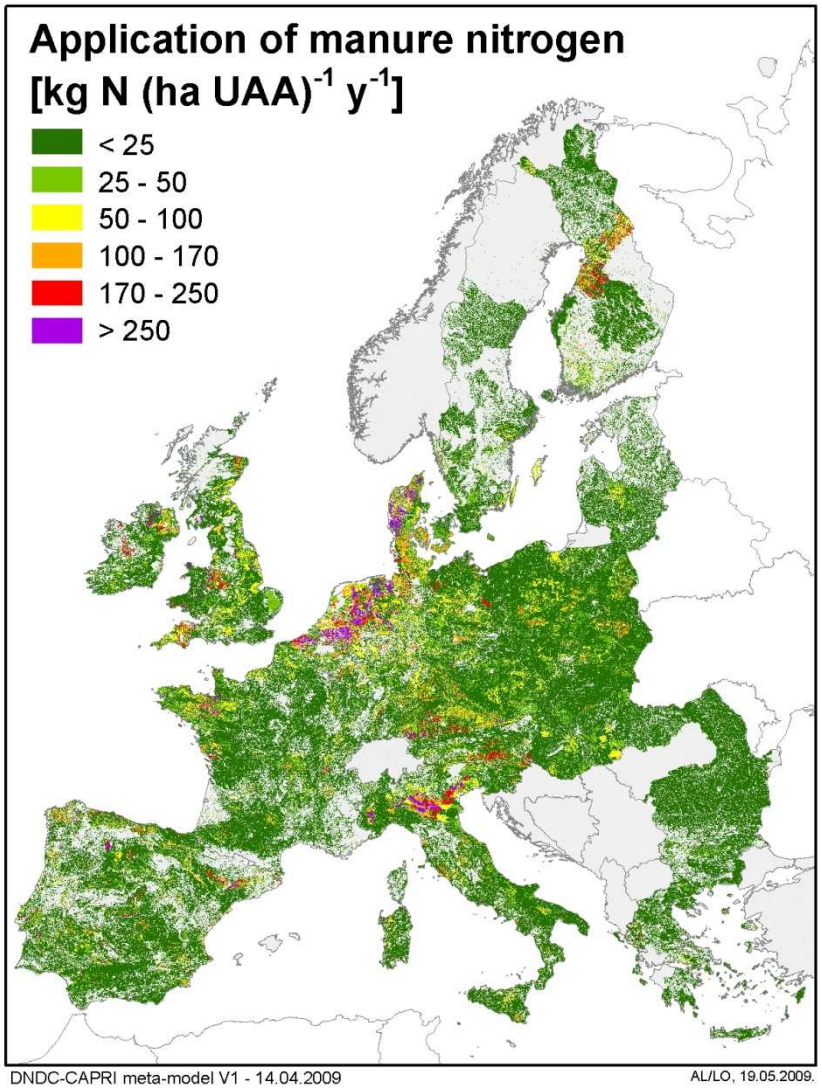
→ **Consistence with regional data ensured through Highest Posterior Method**

Source: Leip et al., 2008, Biogeosciences

Farm management: indicators + input for process-based modelling

capri details

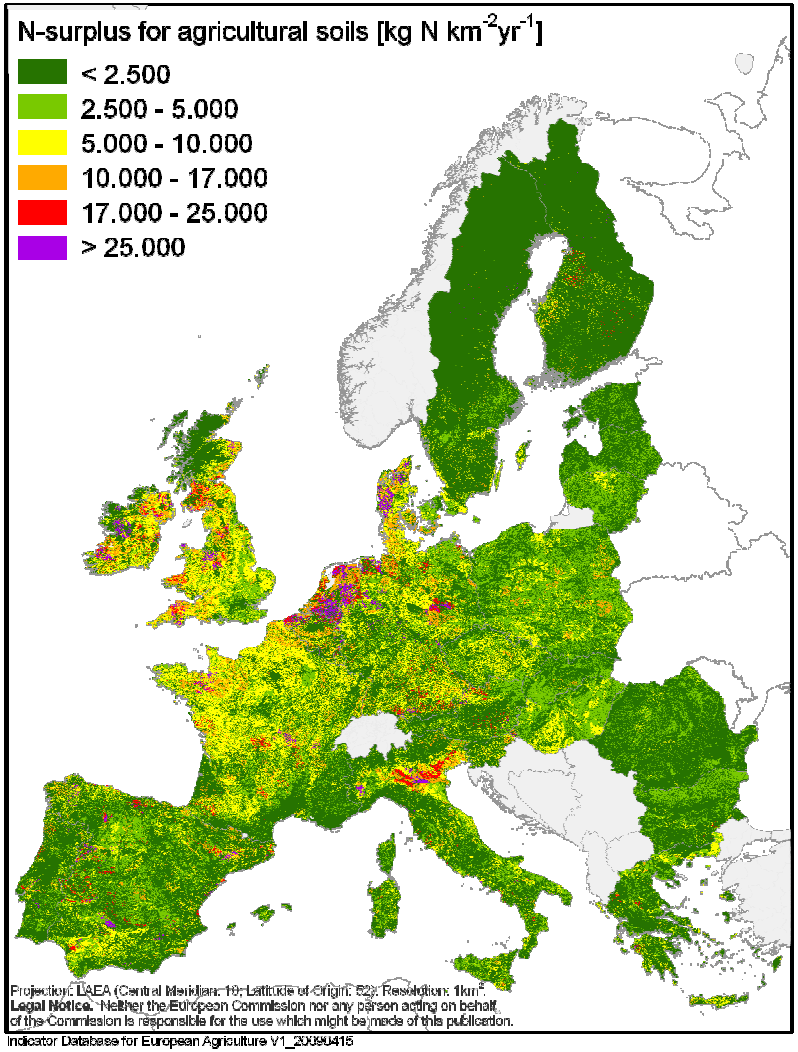


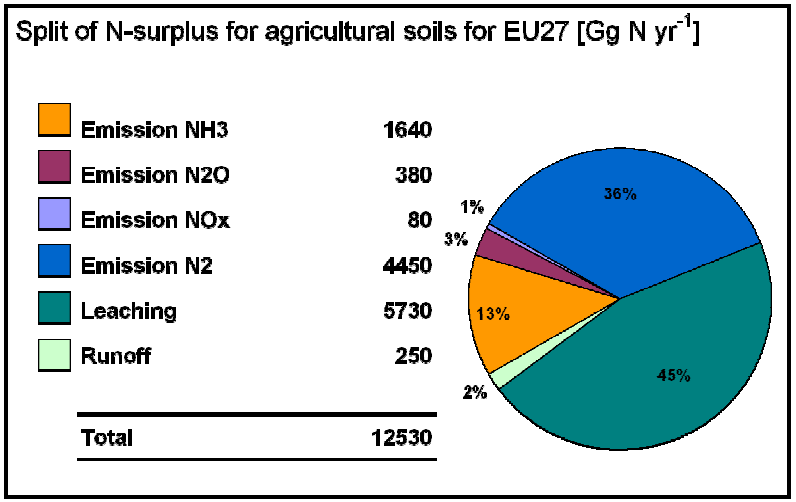


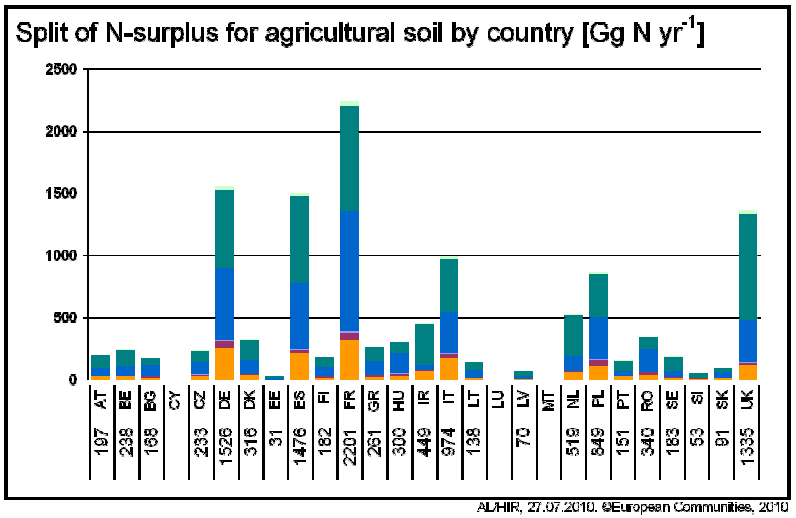
Source: Leip et al., 2008, Biogeosciences

Soil N surplus in Europe

capri details







Source: Leip et al., 2011, European Nitrogen Assessment

Re-aggregation to watershed level

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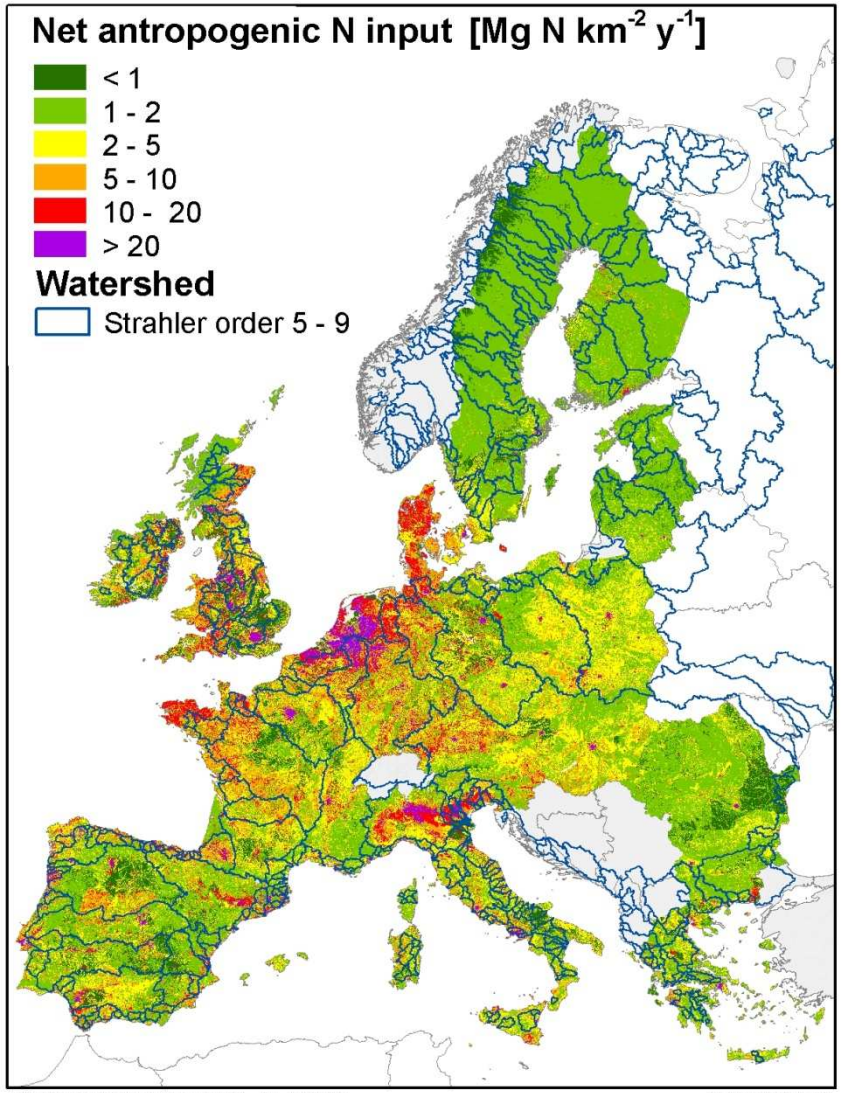

E.g. Net anthropogenic N input to watersheds

→ Throughout Europe, NANI represents 3700 kgN/km2/yr:
5 times the background rate

→ Approx. 78% of NANI does not reach the basin outlet, but instead is *stored* or *eliminated*

→ N delivery to the European marine coastal zone totals 810 kgN/km2/yr (range, 200–4000 depending on the watershed), about four times the natural background

Source: Billen et al., 2011, European Nitrogen Assessment