2030-SCENARIOS FOR SUSTAINABLE LAND-USE AND BIOMASS PRODUCTION FOR BIOREFINING IN DENMARK

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A SYSTEM DESIGN TO MATCH RESOURCE AND DEMAND

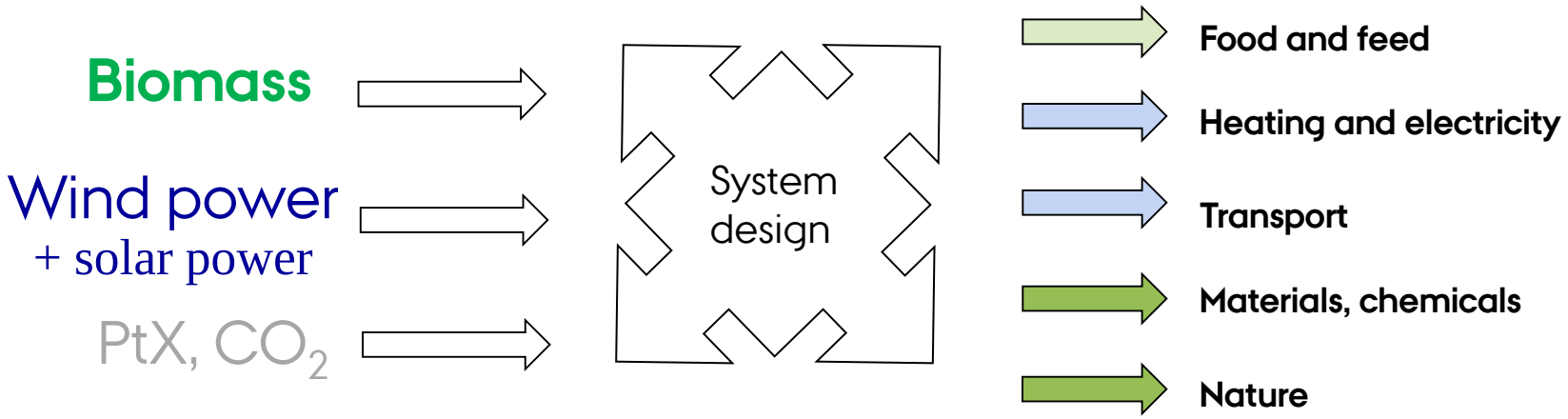


Figure modified from original by Henrik Wenzel, SDU

Green Biorefinery

Human food

Protein concentrate

Fiber

Brown juice

Bio-chemicals and -materials

Figure by Morten Ambye-Jensen, AU

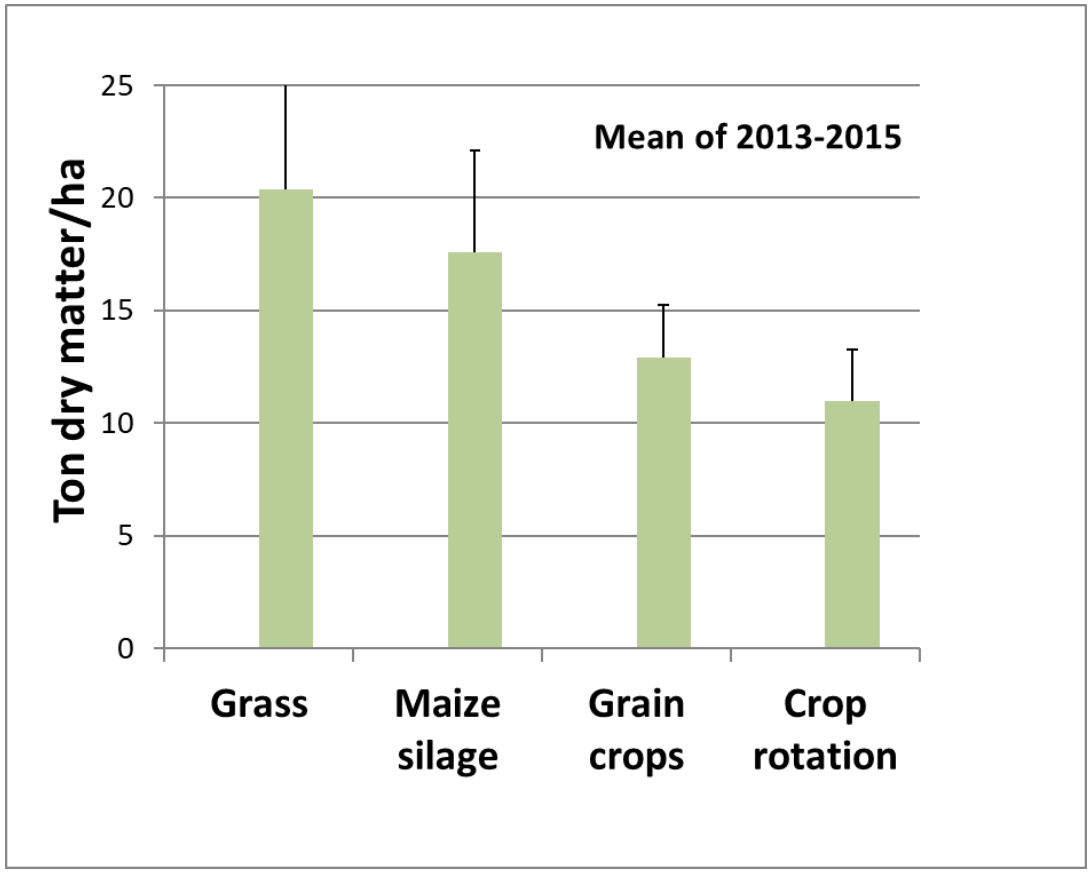
Sustainable intensification - Targeting multiple goals at the same time

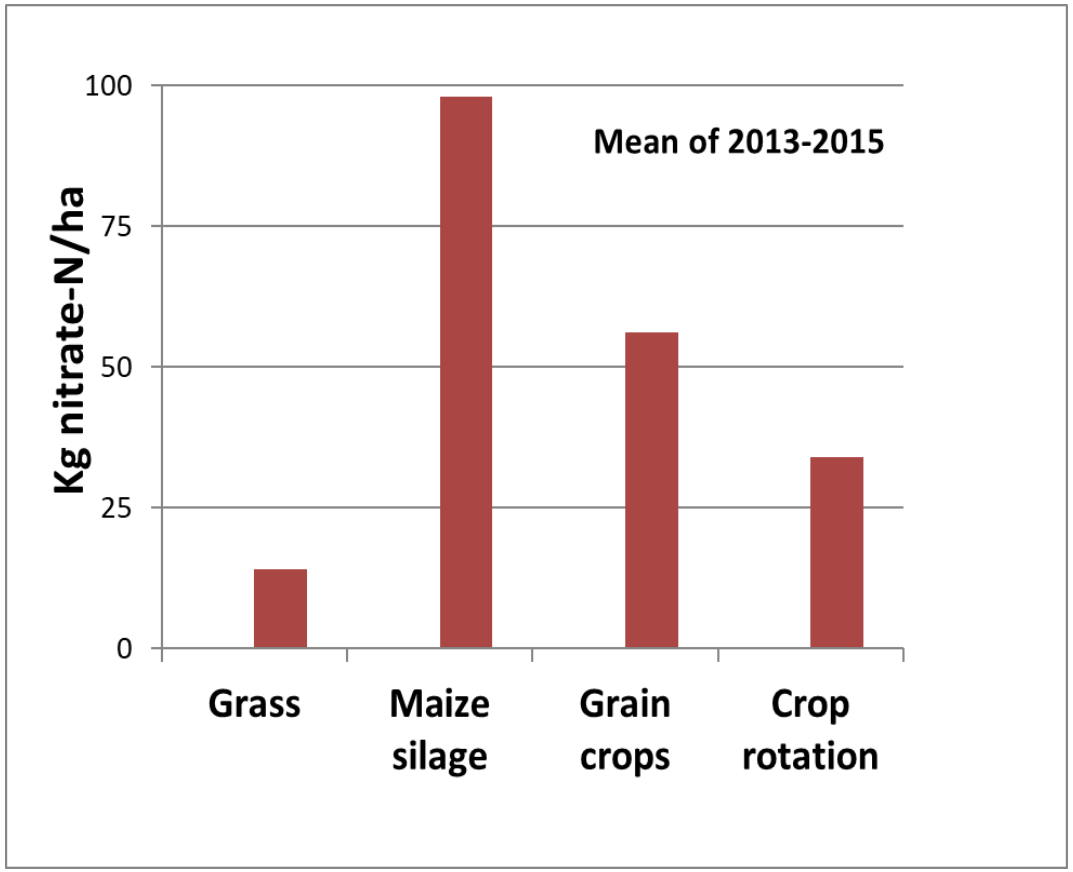
- Increase biomass available for biorefining (incl. energy)
- Increase soil carbon stocks mitigating climate change
- Reduce nitrate leaching
- No - or low - inputs of pesticides and mineral fertilizer
- Room for nature (land-sparing and land-sharing)

An example:

Changing from annual crops to **perennial grass-clover mixtures** expand the period for utilizing solar radiation (more photosynthesis → more C capture → more biomass)

BIOMASS YIELD, N-LEACHING (AND SOIL C)





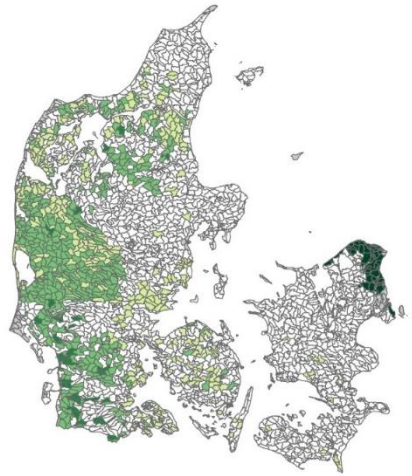
Manevski et al., 2017; 2018

2030-SCENARIOS

To balance different targets, we created scenarios for 2030 with different emphasis:

1. 2015-2019: (baseline)
2. 2030: Business-As-Usual
3. 2030: Biomass scenario (*e.g. maximizing biomass production via sustainable intensification*)
4. 2030: Extensification scenario (*e.g. more emphasis on nature and low-input farming*)

+ Sub-scenarios with changes in animal production (-/+ 20%)

Now → 2030  ?

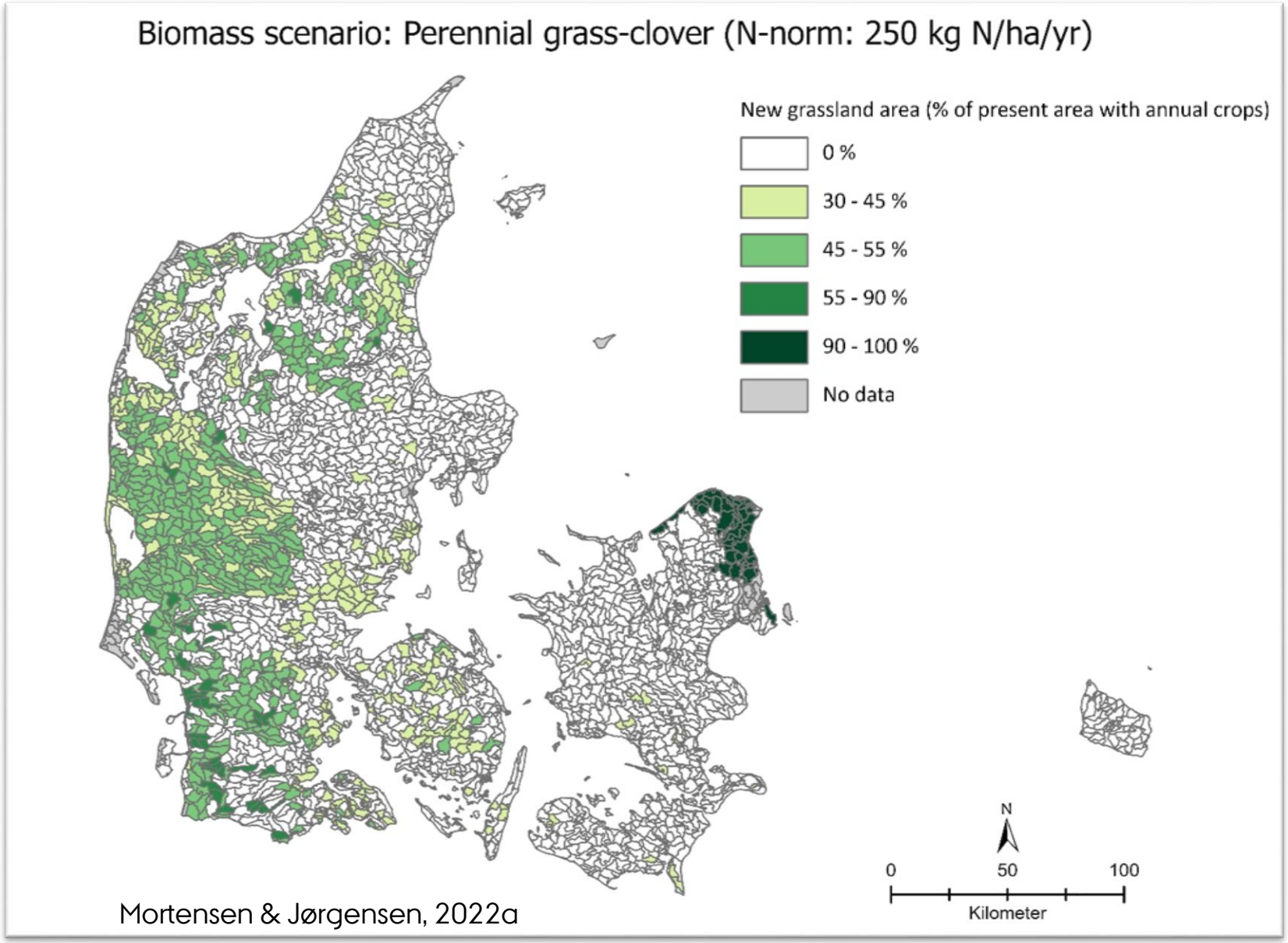
TARGETING

Nitrate-sensitive soils with N leaching to **coastal waters** that do not fulfill the *Water Framework Directive*

Grain, rapeseed and maize converted to **perennial grass-clover** (*4 years + 1 year undersown in spring barley*)
~ 250,000-320,000 ha

+ 45,000 ha sugar beets in the biomass scenario

With the NLES5 model, we estimate that these conversions alone reaches 60% of the missing N reduction targets



Mortensen & Jørgensen, 2022a

TARGETING

Soil carbon

100,000 ha grass-clover on loamy soils with a high Dexter index (*clay:carbon ratio)*

- High potential for soil C storage and stabilization

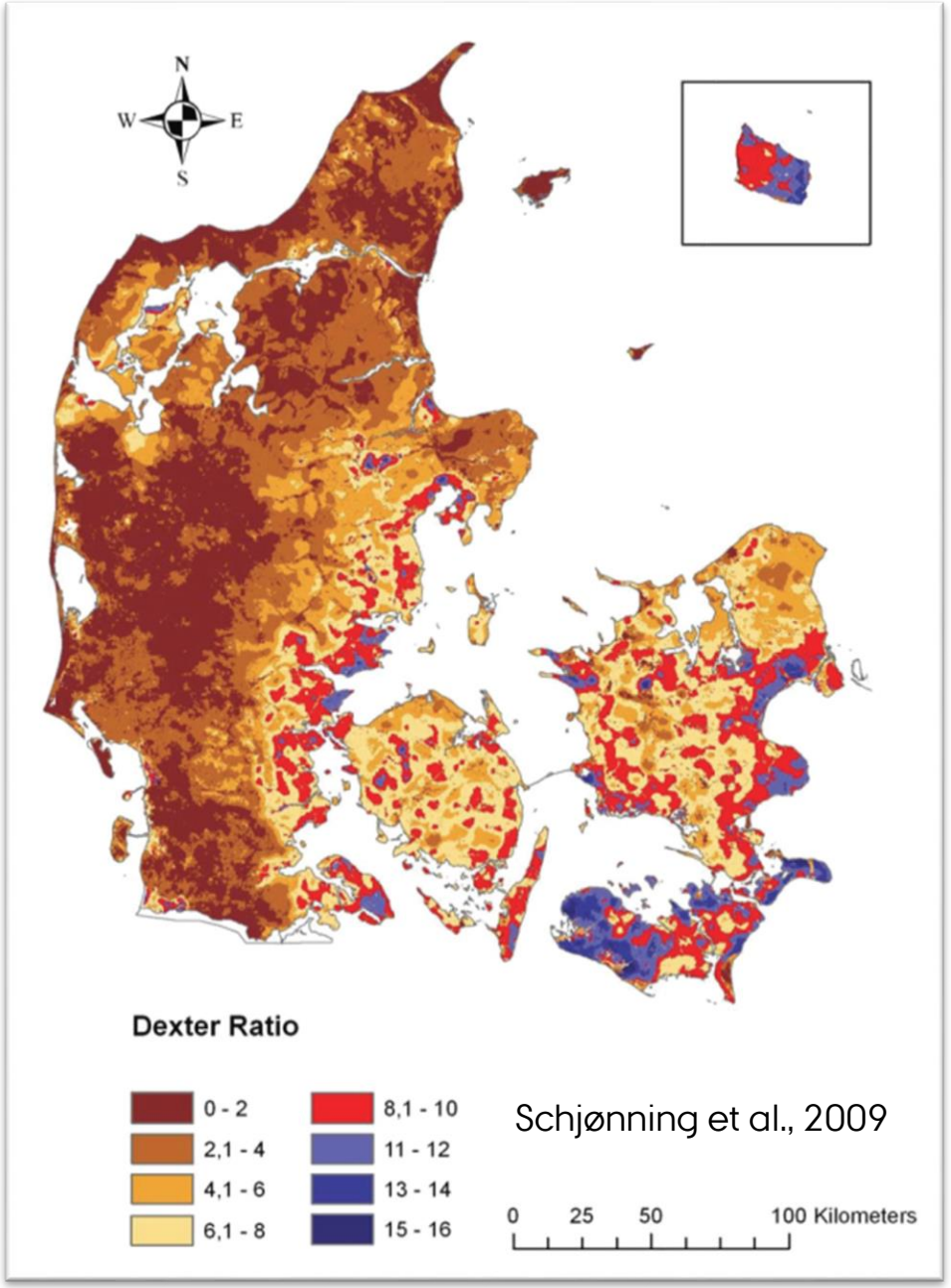
Pesticides, nature conservation, GHG emissions

20,000 ha grasslands on sandy soils in drinking water areas

- Extensive grazing / natural succession

50,000 -100,000 ha rewetted lowland soils

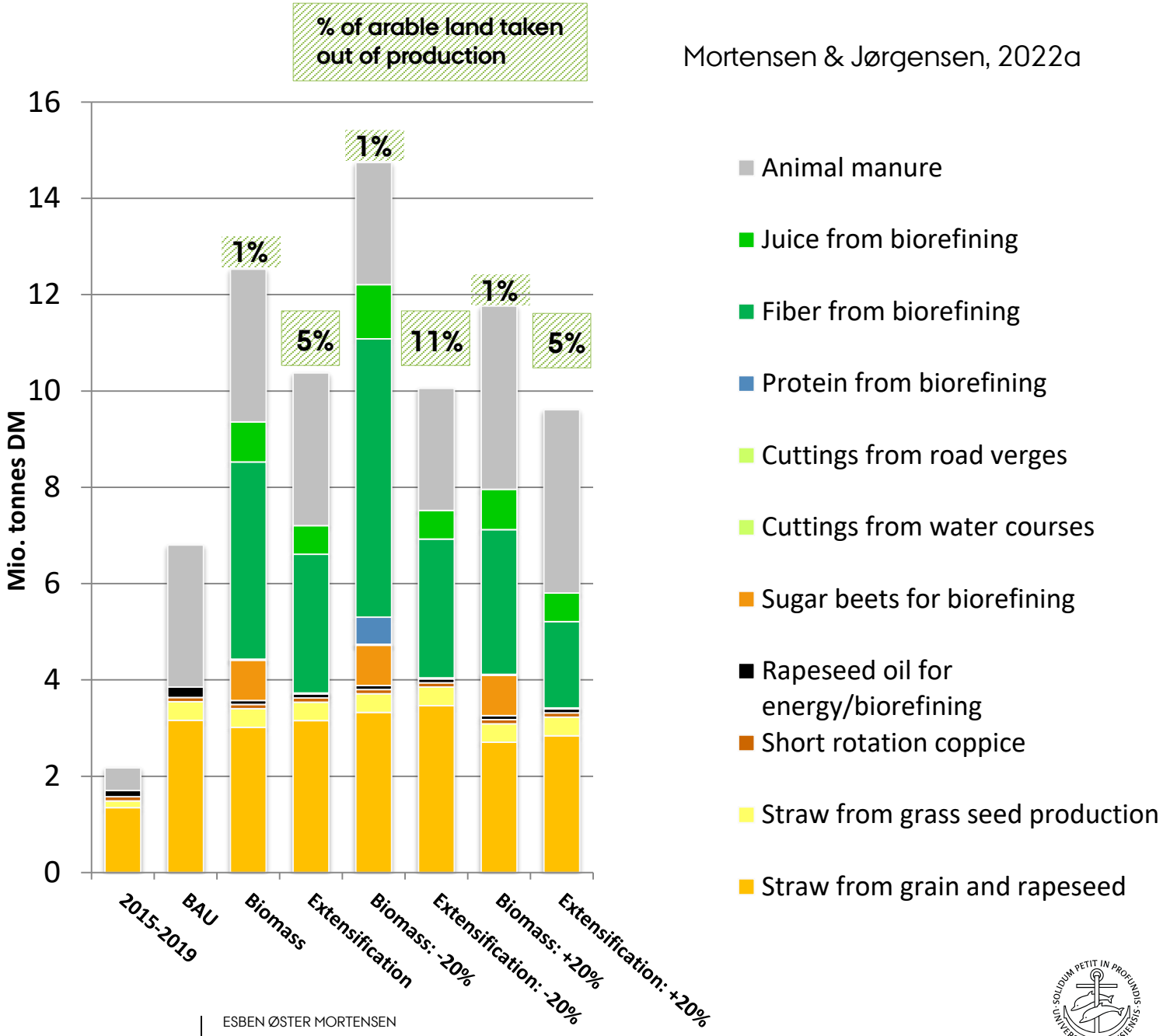
- Paludi-culture / extensive grazing / natural succession



Schjønning et al., 2009

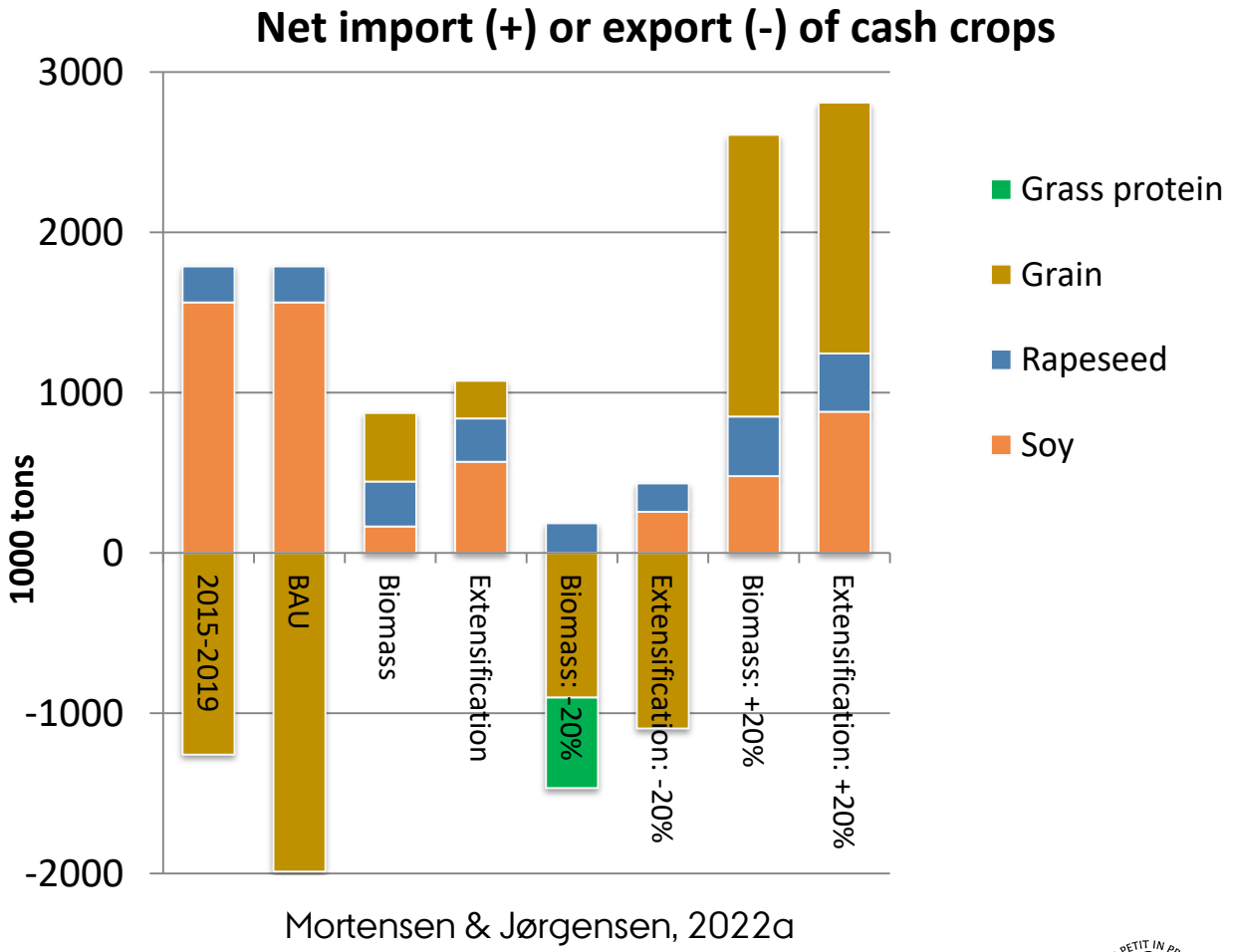
2030 - RESULTS

Total Danish Biomass production for biorefining incl. energy



2030 IMPORT/EXPORT BALANCE

- Grass protein substitutes soy import
- Increased import of grain and rapeseed in some scenarios to compensate for the areas converted to grass-clover
- Surplus grass protein could be refined for human consumption, or parts of the area with grass-clover could be changed into legumes for *direct* human consumptions



Mortensen & Jørgensen, 2022a

USE OF THE SCENARIOS

THANK YOU
FOR YOUR ATTENTION!

- This project was done by AU and KU for the Ministry of Food and Environment

Mortensen & Jørgensen, 2022a,b:

a) Danish agricultural biomass production and utilization in 2030, DCA Advisory memorandum.

b) Forudsætninger for og beregninger af 2030 scenarier for arealanvendelse og biomasse-produktionen i landbruget, DCA notat.

DCA report is about to be published with all project results

- New task for the National Bioeconomy Panel to combine biomass scenarios with energy scenarios for 2030 and 2050

GrassTools

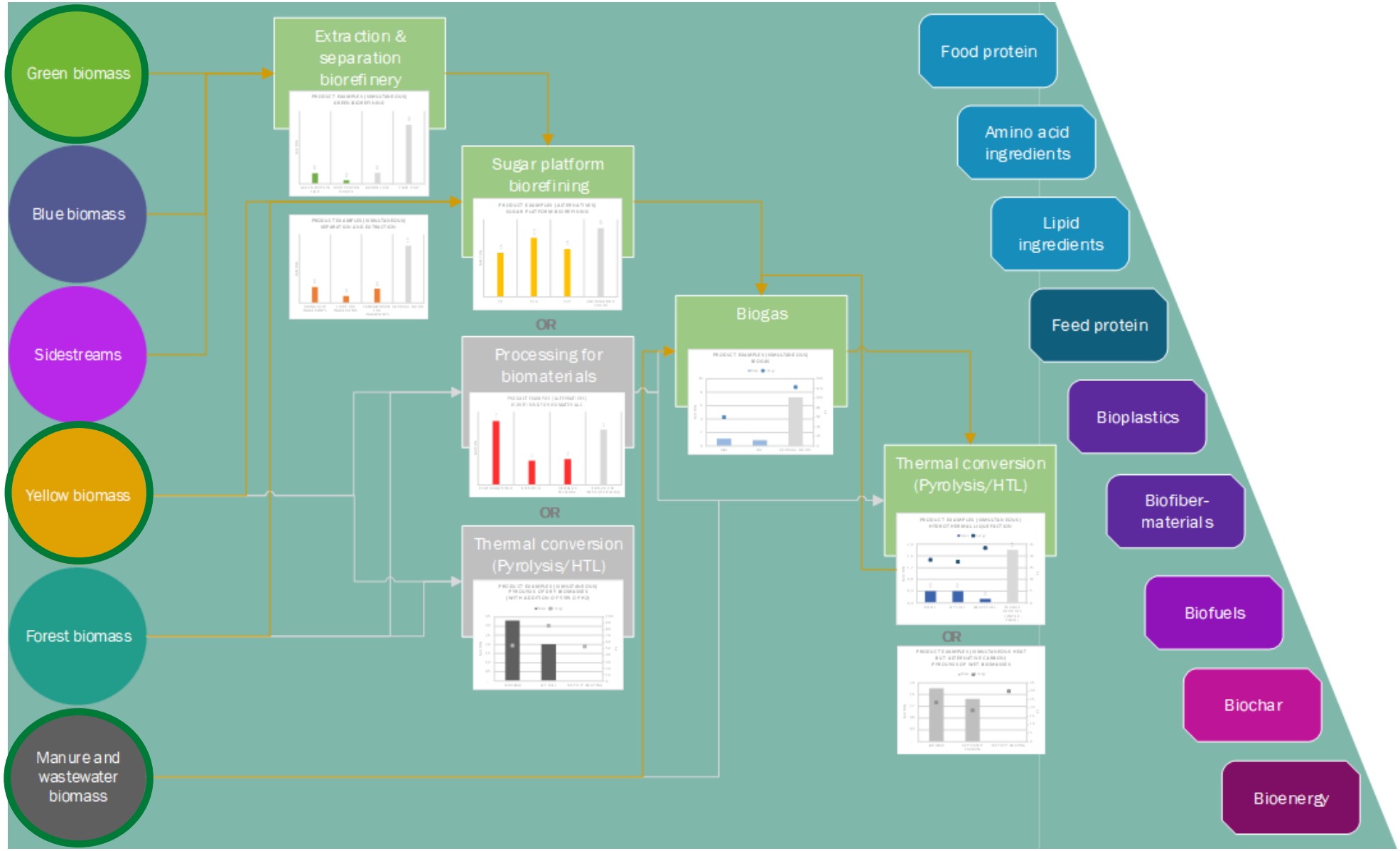
CBIO
AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY

AARHUS
UNIVERSITY

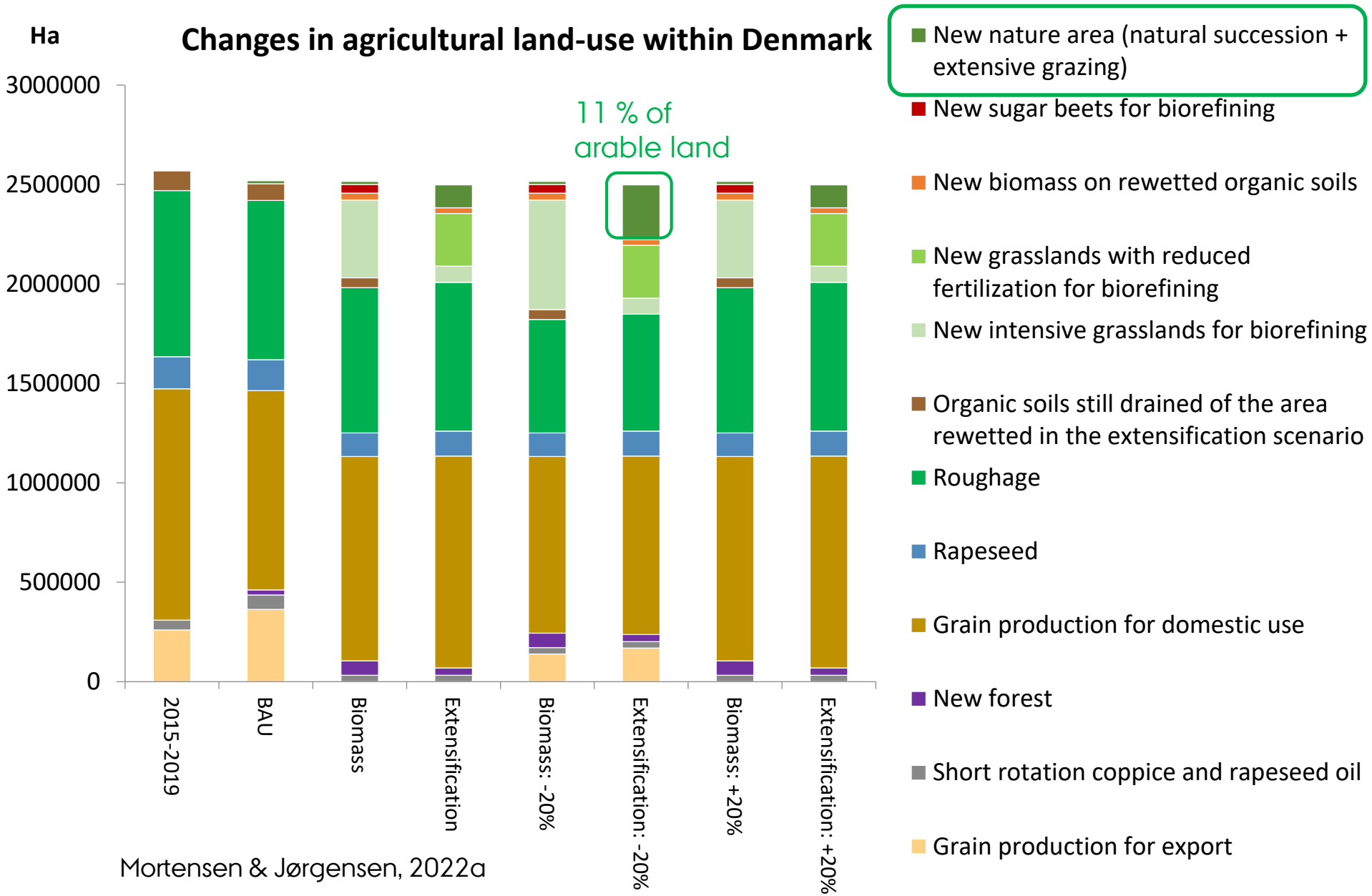
BIOREFINING

Morten Ambye-Jensen, 2022:

Synergier og systemgevinster ved ændret arealanvendelse og bioraffinering, DCA Notat.



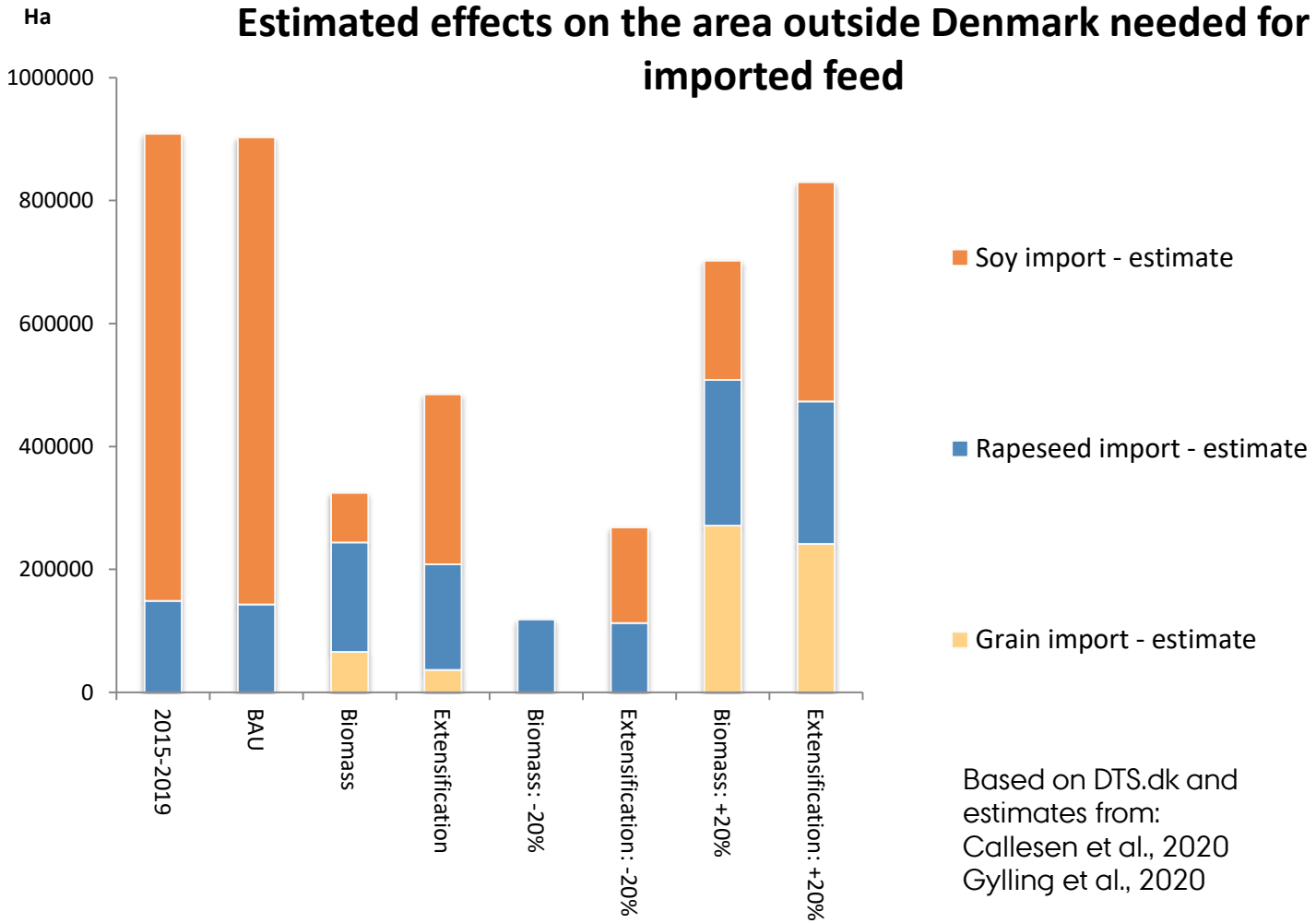
2030



Mortensen & Jørgensen, 2022a

2030

Some scenarios depend more than others on land outside Denmark to sustain crop and animal production within Denmark



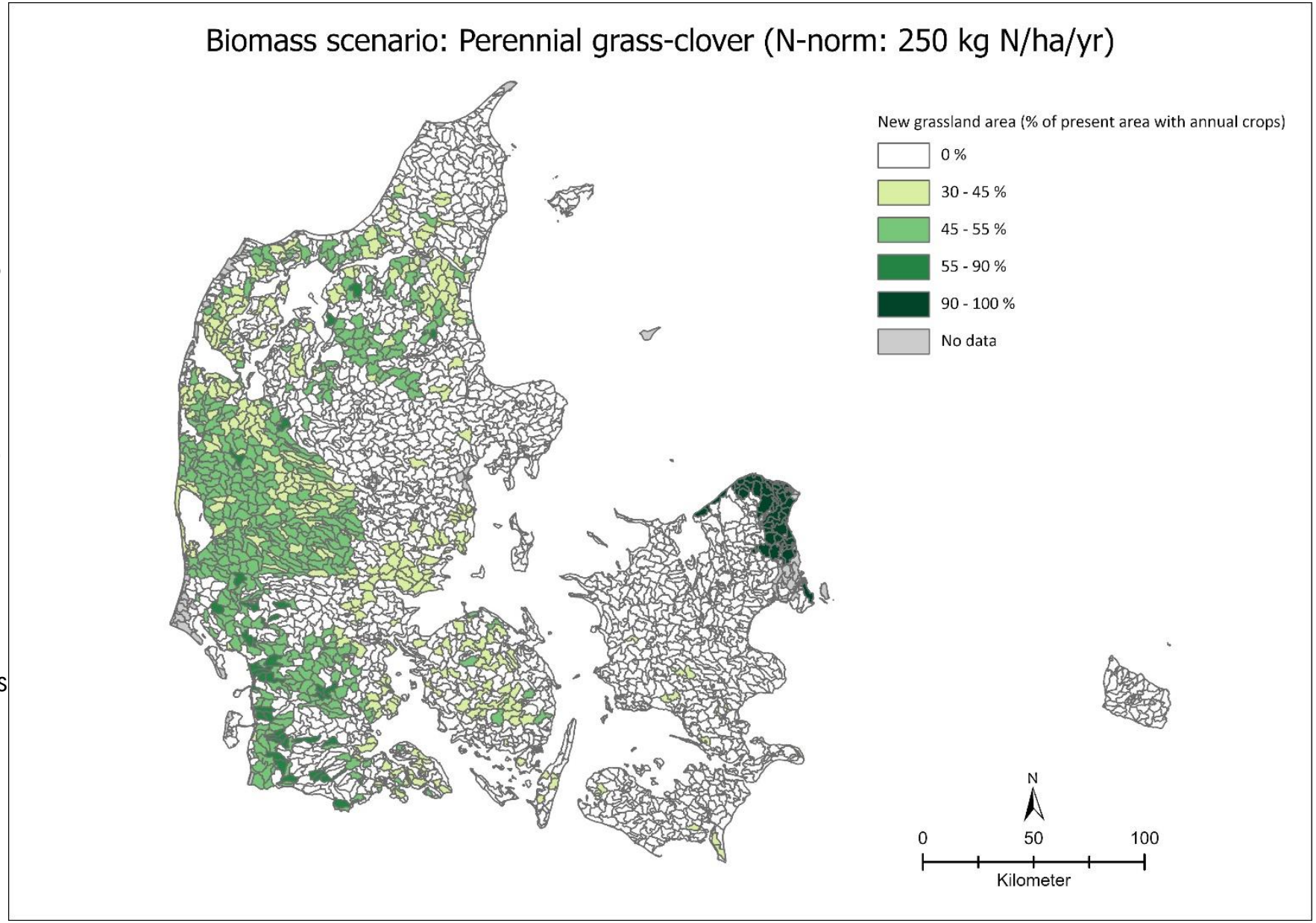
Based on DTS.dk and estimates from:
Callesen et al., 2020
Gylling et al., 2020

Biomass scenario:

Nitrate-sensitive soils with N leaching to **coastal waters** that do not fulfill the *Water Framework Directive*

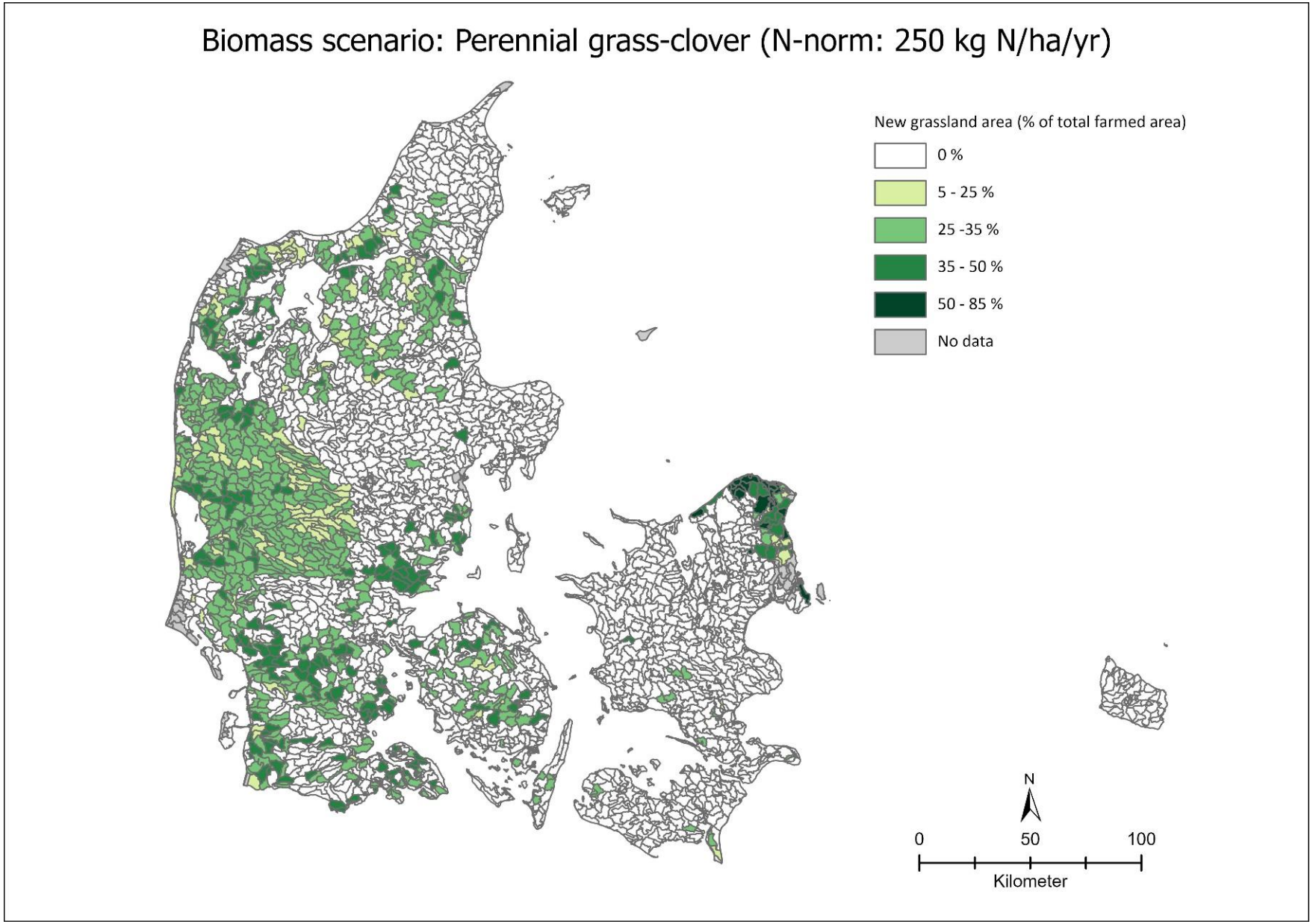
Grain, rapeseed and maize converted to **perennial grass-clover** (*4 years +1 year undersown in spring barley*)
~ 275,000 ha

(+ 45.000 ha of sugar beets in biomass scenario only)



Biomass scenario:

% of total farmed area instead of % of annual crops



Biomass scenario:

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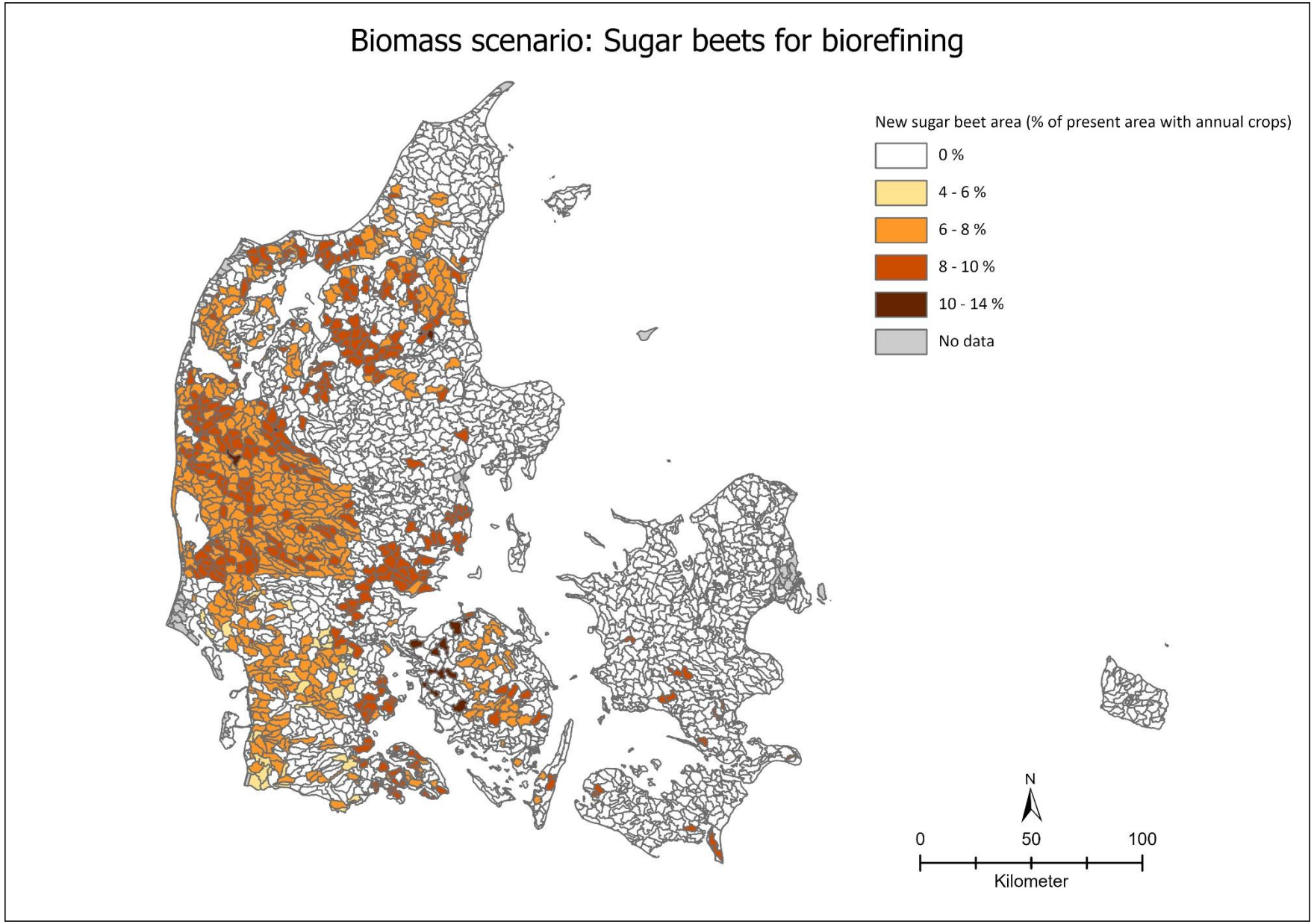
~ 45,000 ha



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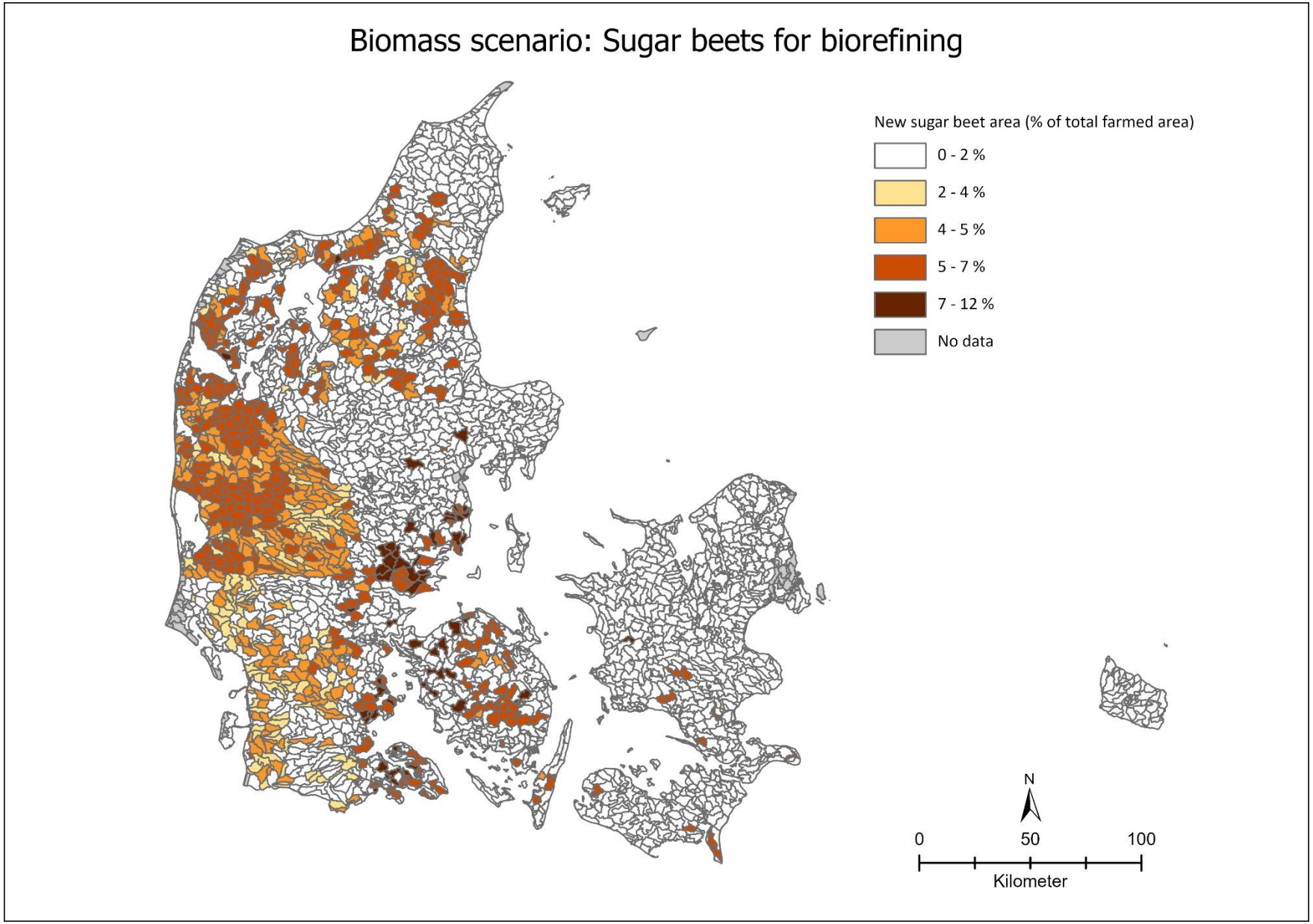
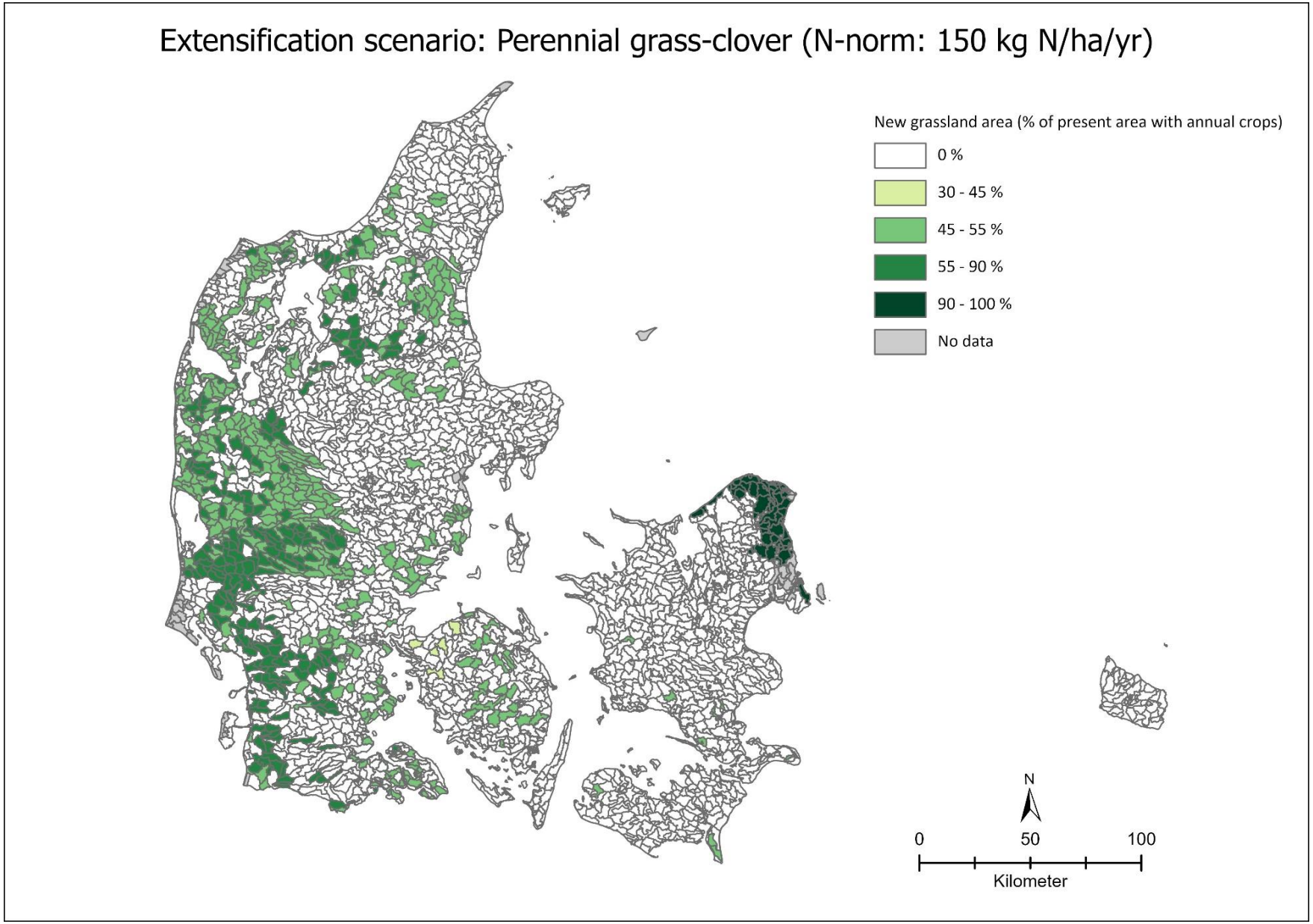


Extensification scenario:

Nitrate-sensitive soils with N leaching to **coastal waters** that do not fulfill the *Water Framework Directive*

Grain, rapeseed and maize converted to **perennial grass-clover** (*4 years +1 year undersown in spring barley*)
~ 250,000 ha



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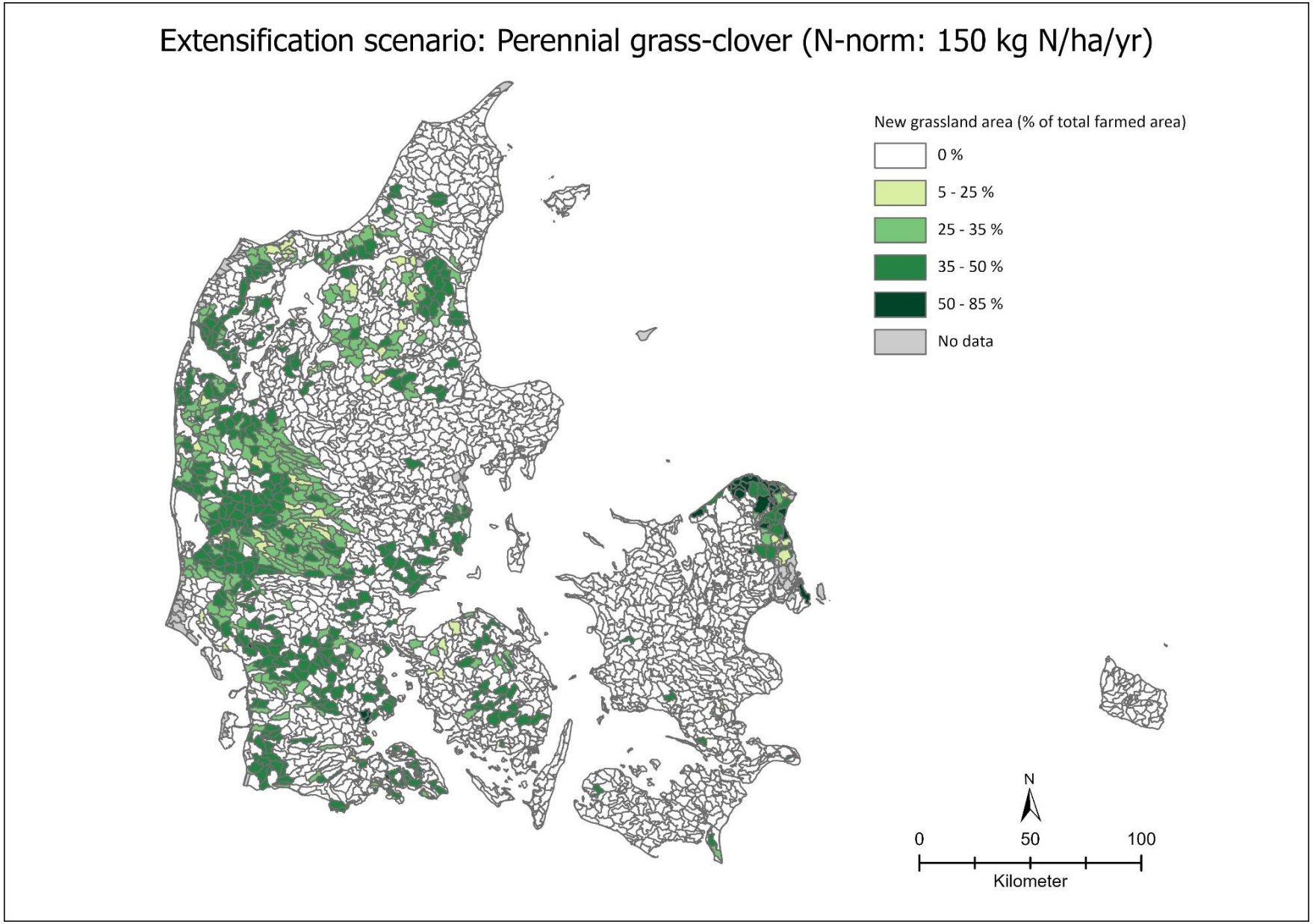
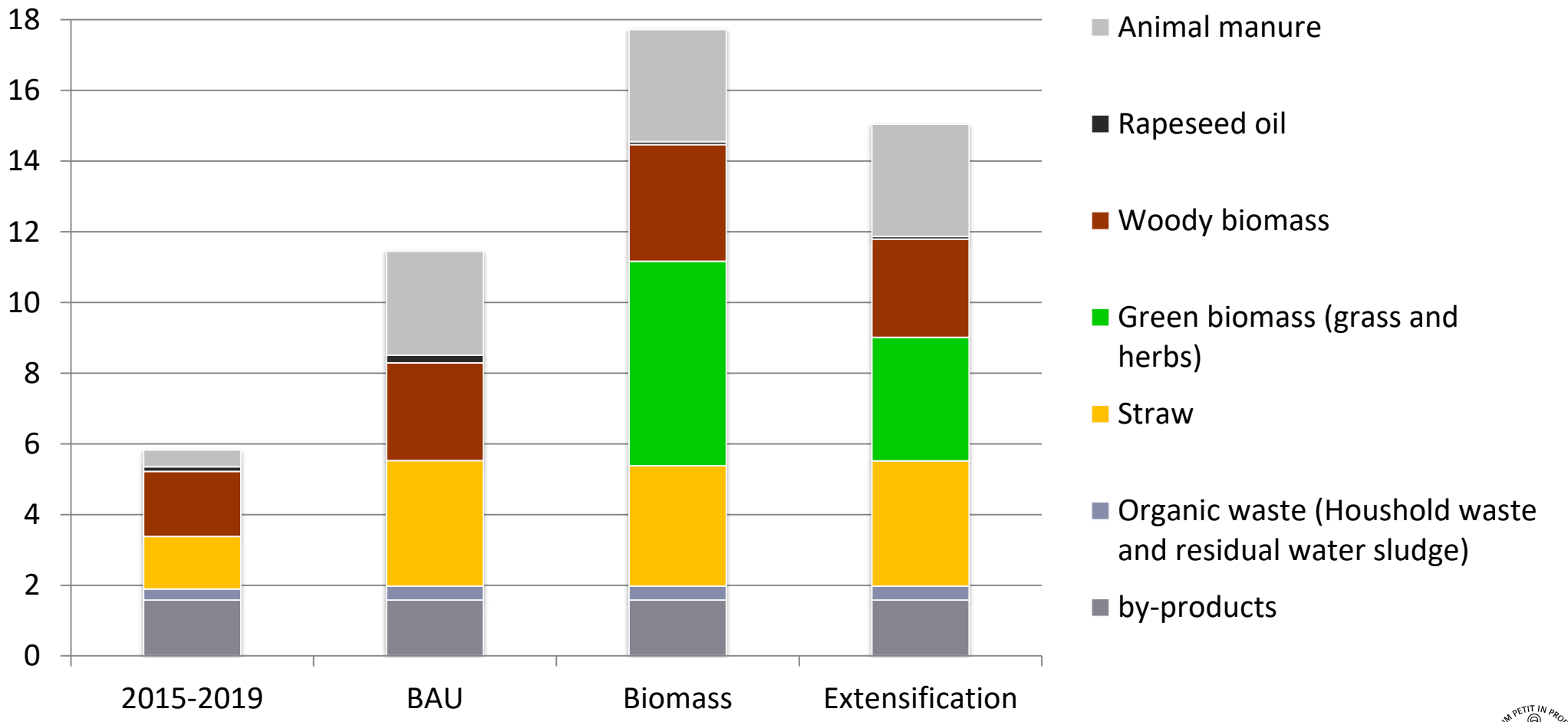


2030

Biomass type



SOME CORE ELEMENTS IN 2030-SCENARIOS

1. Perennial grass-clover for biorefining on different soils types
2. Sugar beets for biorefining
3. 50,000 -100,000 ha rewetted organic soils
4. 200,000 ha of cover crops optimized and harvested for biorefining
5. 15% increased straw recovery and 15% increased straw yield
6. 50-90 % of animal manure goes via biogas before utilized as manure
7. 5.600 ha yr^{-1} afforestation

Mortensen & Jørgensen, 2022a,b:

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