Modelling regional agricultural land use and climate change adaptation strategies in 4 case study regions Northern Germany

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Objectives and approach

Objectives:

• analyse climate change mitigation and adaptation strategies
  • for agricultural and forestry land use
  • under policy scenarios
  • for 4 case study regions in Northern Germany (NUTs 3)
• and discuss resulting land use change and environmental impacts

Approach:

• linear programming farm modelling approach
• prices taken from trade models
• ecological evaluation by bio-physical models
• expert assessments for management options and yields
Four case study regions (NUTs-3) => different with respect to farm size, climate and soil and specialisation

Region: Diepholz Uelzen Fläming Oder-Spree
Typical: livestock irrigation grassland arable land

west east
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as usual (BAU)</td>
<td>• linear yield projections</td>
<td>• price projection by CAPRI price factors (2030 used for 40 &amp; 60)</td>
<td>• Premiums: actual area payments plus greening</td>
<td></td>
</tr>
<tr>
<td>Biodiversity (BDIV)</td>
<td>• 10% of arable land in specific measures</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Climate mitigation and adaptation (CLIM)</td>
<td>• reduced nitrogen use at farm level (20% legumes)</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td>• Transforming of degraded arable fen area into permanent extensive grassland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• airwashing filters and age specific feeding in pig production (ammonia)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
prices as taken from CAPRI baseline  
(Gömann, Kreins TI, Braunschweig)

<table>
<thead>
<tr>
<th></th>
<th>price factor 2020</th>
<th>price factor 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>potatoe</td>
<td>1,13</td>
<td>1,27</td>
</tr>
<tr>
<td>sugar beet</td>
<td>1,35</td>
<td>1,29</td>
</tr>
<tr>
<td>rape seed</td>
<td>1,01</td>
<td>1,23</td>
</tr>
<tr>
<td>barley</td>
<td>0,86</td>
<td>1,09</td>
</tr>
<tr>
<td>triticale</td>
<td>0,87</td>
<td>1,12</td>
</tr>
<tr>
<td>rye</td>
<td>0,87</td>
<td>1,12</td>
</tr>
<tr>
<td>winter wheat</td>
<td>0,86</td>
<td>1,15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Lifestock</strong></th>
<th>price factor 2020</th>
<th>price factor 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>beef</td>
<td>1,02</td>
<td>1,45</td>
</tr>
<tr>
<td>milk</td>
<td>1,02</td>
<td>1,37</td>
</tr>
<tr>
<td>pork</td>
<td>1,27</td>
<td>1,48</td>
</tr>
</tbody>
</table>

- Pig production favoured in 2020
- cereals are disadvantaged especially in 2020 with largest impact on eastern regions
### Results

- Results are presented at three levels of aggregation
  - **Overall aggregation per region**
  - **Aggregation per production orientations: arable, dairy, pig fattening**
  - **Aggregation per farm size type: small, medium and large**

- Results are shown for
  - average costs and benefits per region
  - income indicators at all three aggregation levels:
    - income/ha,
    - income/labourer,
    - subsidies in relation to ...
  - land use distribution per region
Number of farms represented per farm type and region

<table>
<thead>
<tr>
<th>Region</th>
<th>Diepholz</th>
<th>Uelzen</th>
<th>Flaeming</th>
<th>Oder-Spree</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of farms</td>
<td>1371</td>
<td>493</td>
<td>82</td>
<td>86</td>
</tr>
</tbody>
</table>

- **Diepholz**: Mixed 60%, Cattle 20%, Pig 10%, Arable 10%
- **Uelzen**: Mixed 40%, Cattle 50%, Pig 10%, Arable 10%
- **Flaeming**: Mixed 30%, Cattle 30%, Pig 20%, Arable 20%
- **Oder-Spree**: Mixed 10%, Cattle 60%, Pig 30%, Arable 10%
average farm size in ha arable and grassland for small (<100 ha), medium and large (>250 ha) farms

- Grassland (ha)
- Arable land (ha)
- No of farms

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**Diepholz**

- Small: 10 ha
- Medium: 11 ha
- Large: 37 ha

**Uelzen**

- Small: 11 ha
- Medium: 7 ha
- Large: 12 ha

**Flaeming**

- Small: 27 ha
- Medium: 93 ha
- Large: 51 ha

**Oder-Spree**

- Small: 120 ha
- Medium: 234 ha
- Large: 51 ha

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**Dairy cows**

- Small: 0
- Medium: 20
- Large: 40

**10 pigs**

- Small: 0
- Medium: 20
- Large: 40

**Bulls**

- Small: 0
- Medium: 20
- Large: 40
Results

- Results are presented at three levels of aggregation
  - Overall aggregation per region
  - Aggregation per production orientations: arable, dairy, pig fattening
  - Aggregation per farm size type: small, medium and large

- Results are presented as
  - revenues versus all costs per region
  - farm income indicators at all three aggregation levels:
    - income/ha,
    - income/labourer,
  - land use distribution per region
Legend explanation - and level of revenues

- area costs
- depreciation livestock stables
- fixed costs machinery
- overhead material costs
- labour costs management
- labour costs production
- variable costs machinery (€/a)
- direct costs

long term investment
medium term investment

overhead
production costs

Farm income: sales + premiums - all variable and fixed costs (without land and labour costs)
Revenues versus total costs

Diepholz

BAU 2010
Business as usual (BAU): changes over time - Diepholz (west)

The diagram illustrates the changes in costs and income over time for Diepholz (west). It shows the distribution of costs and income across different categories such as area costs, depreciation livestock stables, fixed costs machinery, overhead material costs, labour costs management, labour costs production, variable costs machinery (€/a), and direct costs. The data is presented in millions for each year: 10, 20, 40, and 60 years.
Business as usual: changes over time - Oder Spree (east)

<table>
<thead>
<tr>
<th></th>
<th>costs</th>
<th>income</th>
</tr>
</thead>
<tbody>
<tr>
<td>area costs</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>depreciation livestock stables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fixed costs machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>overhead material costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>labour costs management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>labour costs production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>variable costs machinery (€/a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>direct costs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Millions

Oder-Spree
Scenarios over time - Diepholz (west)
Scenarios over time - Oder Spree (east)

- area costs
- depreciation livestock stables
- fixed costs machinery
- overhead material costs
- labour costs management
- labour costs production
- variable costs machinery (€/a)
- direct costs

Millions

10 | 20 | 40

BAU
BDIV
CLIM
Results per region

farm income per person resp. per ha
Results per region

Income per person [€/WF]

- BAU
- BDIV
- CLIM

Diepholz
Uelzen
Flaeming
Oder-Spree

Income per person [€/WF]
Results per region

Income per ha

- BAU
- BDIV
- CLIM

Diepholz
Uelzen
Flaeming
Oder-Spree
Results per region

Income losses per scenario compared to BAU (€/ha)

<table>
<thead>
<tr>
<th></th>
<th>BAU</th>
<th>BDIV</th>
<th>CLIM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diepholz</td>
<td>Uelzen</td>
<td>Flaemling</td>
</tr>
<tr>
<td>10</td>
<td>-31</td>
<td>-175</td>
<td>-28</td>
</tr>
<tr>
<td>20</td>
<td>-15</td>
<td>-155</td>
<td>-12</td>
</tr>
<tr>
<td>40</td>
<td>-19</td>
<td>-167</td>
<td>-13</td>
</tr>
<tr>
<td>60</td>
<td>-20</td>
<td>-172</td>
<td>-13</td>
</tr>
<tr>
<td></td>
<td>-16</td>
<td>-55</td>
<td>-11</td>
</tr>
<tr>
<td></td>
<td>-8</td>
<td>-34</td>
<td>-9</td>
</tr>
<tr>
<td></td>
<td>-35</td>
<td>-36</td>
<td></td>
</tr>
</tbody>
</table>
Results per specialisation:

arable, pig, mixed and cattle (dairy & bull fattening) farms
Results for arable, pig, mixed and cattle (dairy&bull fattening) farms

Baseline: income per person [€/WF]

Livestock farmers profit over time while arable farmer see reduced incomes.
Results for arable, pig, mixed and cattle (dairy & bull fattening) farms

Baseline: income per ha

Diepholz
Scenario impact on farm types in Diepholz

Income [€/WF]

- Income goes down with the scenarios
- clim more than bdiv - always same pattern as in bau in all regions
Income losses by farm type per scenario compared to BAU (€/ha)
Results for small, medium and large farms
Results for small, medium and large farms

Baseline: income per person [€/WF]
Results for small, medium and large farms

Income losses per scenario compared to BAU (€/ha)

Diepholz

Oder-Spree

large  medium  small

BAU  BDIV  CLIM  BAU  BDIV  CLIM  BAU  BDIV  CLIM  BAU  BDIV  CLIM

0  -50  -100  -150  -200  -250

10  20  40  60
Land use

cereals
  • are reduced in 2020 and a bit less in 2040

maize production
  • increases with higher bioenergy production from 2020 onwards

set aside
  • Oder-Spree and Uelzen show larger shares of set aside in 2020 and a bit less also in 2040
  • Less in biodiv and clim scenarios, due to conservation areas there

sugar beet production
  • increases up to the rotational restrictions => market effect?
Conclusion

• The model reacts sensible
  • to resource endowment of a farm type
  • price changes
  • available production options
  • policy instruments

• Ecological evaluation of land use change is still under work
  • Nitrogen leaching
  • GHG
  • Biodiversity indicators
Conclusion

- business as usual scenario show income losses for 2020 and again for 2040 (CAPRI 2030) for most farm types and regions.
  - Diepholz farms can compensate through high bioenergy production levels
  - pig farms also high income increase for 2020 due to the specific price structure
- arable farms have in general highest incomes, followed by pig farms and then by mixed and dairy and bull fattening farms.
- arable farms suffer under future price development while livestock farms profit from projected prices.
- biodiversity scenario results in losses of 10 to 30 €/ha
- climate mitigation scenario causes high losses especially for livestock farms (in western region between 150 and 200 €/ha)
- farms in Oder-Spree rely most on subsidies for mid and long term success
Methodological questions

• Why not use FADN data and PMP?
  • First assumption was: climate adaptation will need new crops and production techniques => not suited for PMP
  • Costs and benefits would change through climate impact and not be reflected by statistical data: therefore expert/model based production practices and costs calculations based on standard data for applied technologies

• Why should we?
  • Difficulties to calibrate, as several attractive crops are limited due to contract based cultivation (e.g. potatoes in Uelzen “the potatoe mafia”)
  • Standard cost calculations seem to overestimate production costs, as larger farms have purchasing and selling mechanisms that result in more favourable prices.
Outlook and improvements planned

• Integration of ecological evaluation results
• Elaboration of a more efficient premium structure for both scenarios.

• In context of MACSUR we will link up with HERMES (Kersebaum) and look at irrigation as one adaptation measure.
Thank you for listening