Integrated assessment of farm level adaptation in Flevoland, the Netherlands: what did we learn from multiple methods and model chains?

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MACSUR Science Conference 2017, Berlin
Introduction

- CC impact assessment requires
  - farming systems analysis
  - integrated assessment

- However
  - multiple models to assess changes in drivers
  - farms are complex and diverse systems: many assumptions

- Objective
  - evaluate impact of different models and assumptions
  - on impacts of CC on arable agriculture in Flevoland, NL
Central: farm models

multiple drivers

Climate change
Technological development
Markets
Policy

farm diversity

Size
Intensity
Specialization
Orientation
Resources
Constraints
Objectives
Farm plans, inputs & outputs

multiple indicators

Economic
Environmental
Social

Reidsma et al. (2015)
Three studies

CC scenarios
- NATIONAL
- SRES
- SIMPLACE

Crop model
- WOFOST
- CAPRI v1
- SIMPLACE
- FSSIM v1
- FSSIM v2

Market model
- CAPRI v1
- CAPRI v2

Farm models
- 75 farms (FADN)
- 2 farm types (FADN)
- 6 farms (interviews)

AgriAdapt project
Kanellopoulos et al. (2014)
Reidsma et al. (2015)

LIAISE project
Wolf et al. (2015)
Webber et al. (2015)

PhD project
Mandryk et al. (2017)
Schaap et al. (2013)
Climate change impacts on yields

- Onion: \(-1\) — +44%
- Sugar beet: \(+6\) — +33%
- Potato: \(-3\) — +22%
- Winter wheat: \(+5\) — +20%
- With technology change: ++
- Extreme events: --
  - affect potato and seed onion yields, with damage up to 88%
  - sugar beet and winter wheat are little affected

Main risk:
Heat wave causing second growth in potato
Comparing studies: yields & prices

- Kanellopoulos et al. (WOFOST) >> Wolf et al. (SIMPLACE)
- Mandryk et al.: effect of extreme events potentially larger

\[ \text{C = climate change} \]
\[ \text{T = technological development} \]
\[ \text{P = price change} \]

- Kanellopoulos et al. (WOFOST) >> Wolf et al. (SIMPLACE)
- Mandryk et al.: effect of extreme events potentially larger
Three farm models

<table>
<thead>
<tr>
<th>FSSIM v1</th>
<th>FSSIM v2</th>
<th>FarmDesign</th>
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<tbody>
<tr>
<td>Mathematical programming</td>
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<td>Genetic Algorithms</td>
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<tr>
<td>Profit maximization</td>
<td>Profit maximization + PMP</td>
<td>Five objectives</td>
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<td>Whole farm activities</td>
<td>Crop rotation activities</td>
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Crop model
- WOFOST
- SIMPLACE

Market model
- CAPRI v1
- CAPRI v2

Farm model
- FSSIM v1
- FSSIM v2
- FarmDesign

CC scenarios
- NATIONAL SRES
- SRES
Base year: farm plans & gross margins

Average of 75 single farms

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<tr>
<th>Area (ha/farm)</th>
<th>Observations</th>
<th>Simulations</th>
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<td>9.2 (18.7%)</td>
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Average of 2 farm types

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Gross margin (€/farm)

- Out of farm
- Other arable
- Vegetables
- Soft wheat
- Potato
- Sugar beet
- Gross margin

Mandryk et al:
- 6 farms
- more vegetables
- GM mean: 193 k€
- GM min: 90 k€
- GM max: 317 k€

Aggregation of farm data affects base year results

Tsutsumi (2015)
What about changes?

Tsutsumi (2015)
### AgriAdapt

<table>
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<th>Base year</th>
<th>C</th>
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### LIAISE

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### Tsutsumi (2015)
What about changes?

Tsutsumi (2015)
Impacts on crop areas

• Climate change
  
  Wheat area: +2 to +35%
  Sugar beet: up to -5% (quota)
  Potato: -32% to 0%
  Vegetables: -1% to +29%

  direction consistent, depends mainly on:
  • relative yields
  • sugar beet quota constraint

  farmers objective SOM: wheat
  farmers objective GM: potato, onion + adaptation

• All changes
  
  up to -16%
  -38% to +26%
  -13% to +55%
  -63% to +16%

  size differs
  • land constraint (rent)
  • activities: mono-cropping

  more variable
  depends mainly on:
  • price scenario
  • land constraints (rent)
  • activities: mono-cropping

Kanellopoulos et al. (2014), Wolf et al. (2015)
Impacts on gross margins

Climate change:
+14.2% to +30.0%
higher yield changes by WOFOST

-2.7% to +3.3%
lower yield changes by SIMPLACE

All changes:
-73% to +99%
price & technology change

+3.8% to 28%
demand elasticities improved; price changes compensate technology change

+ 15% to +43%
per farm plan, with adaptation to extreme events, no farm level adaptation: when policies not constraining, GM can increase more than yields
Impacts on environment

- **Crop protection & fertilizer costs**
  - change according to yields & prices
  - + in A1 scenarios, - in B2 scenarios

- **Energy & other input costs**
  - - in A1 scenarios, -- in B2 scenarios

- **Total N input**
  - Changes together with yields & prices: -40% to +40%

- **N2O emissions & N leaching**
  - Similar as total N input, but smaller due to increase N use efficiency

- **NH3 emissions**
  - Similar as above, but smaller due to improved manure appl. techniques

- **Soil Organic Matter**
  - Farmers preferred farm plans: -8% to +42%
Flevoland in 2050?

Kanellopoulos et al. (2014) and Wolf et al. (2015) projected different outcomes for crop cultivation in Flevoland.

- Gross margin 99% up for Kanellopoulos et al. (2014).
- Gross margin 28% up for Wolf et al. (2015).

Mandryk et al. (2017) suggested SOM = objective more wheat, while Nakasaka (2016) pointed out that land exchange with dairy farms allows 21% more potato area.
Main conclusions (1)

- **Drivers**
  - Impacts of technology and price changes > climate change, for gross margin
  - Positive impacts of average climate change may be counterbalanced by negative impacts of extreme events, but adaptation measures are available
  - Future research: extreme events & stochasticity

- **Models providing input to farm model**
  - Direction of changes in gross margins are mainly influenced by results from crop (yield) and market models (prices); size of change depends on constraints
Main conclusions (2)

• Constraints
  – Changes in farm plans are mainly influenced by assumptions regarding resources and constraints, specifically the available land for rent: we need to consider cooperation between arable & dairy farmers
  – When policy constraints are neglected, impacts on gross margin are more positive
  – Future research: farm structural change & cooperation (see also Mandryk et al., 2012, Reidsma et al., 2015, Nakasaka, 2016)

• Objectives
  – When considering soil quality as important objective, adaptation at farm level will be different: instead of more high value crops, farms will grow more cereals; cooperation with dairy farms also relevant

• Climate change impacts depend on assumptions, but when making this transparent, it can inform adaptation
For further information please visit: www.macsur.eu
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