Modelling European Agriculture with Climate Change for Food Security

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

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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

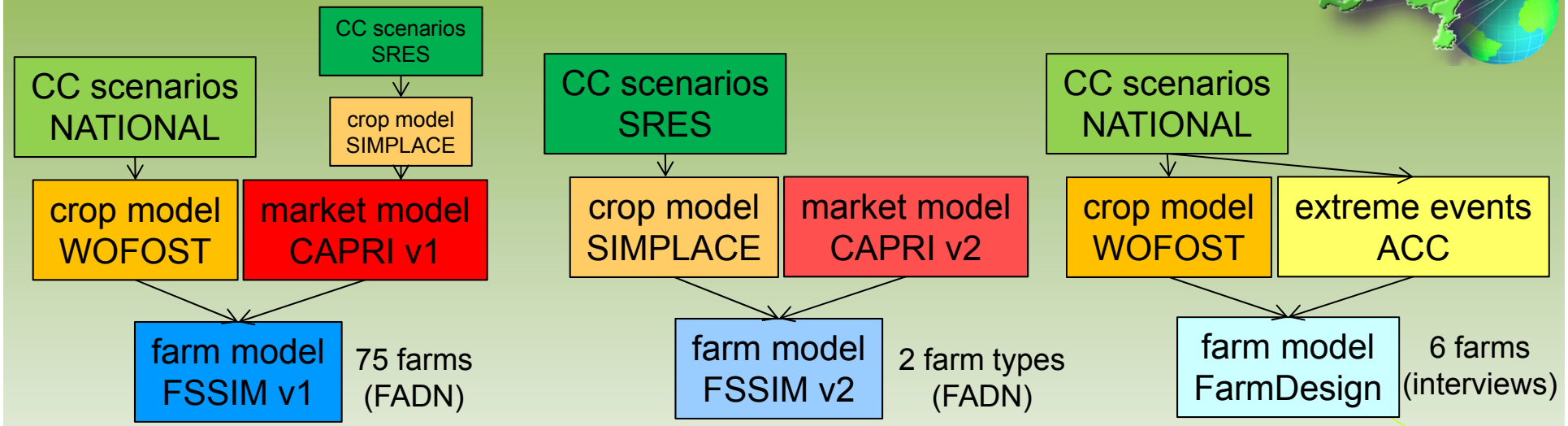
Reidsma et al. (2015)







Three studies



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

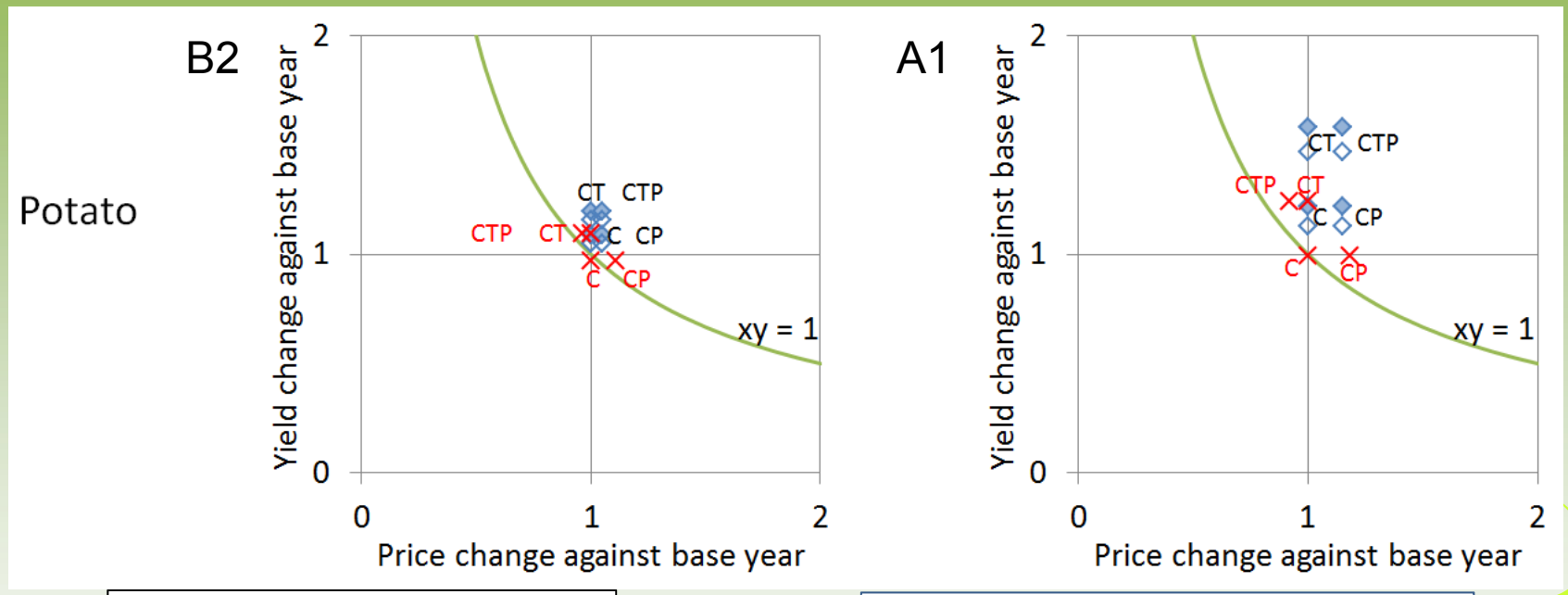
- Onion: -1 – +44%
- Sugar beet: +6 – +33%
- Potato: -3 – +22%
- Winter wheat: +5 – +20%

All scenarios & models: mainly +

- 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

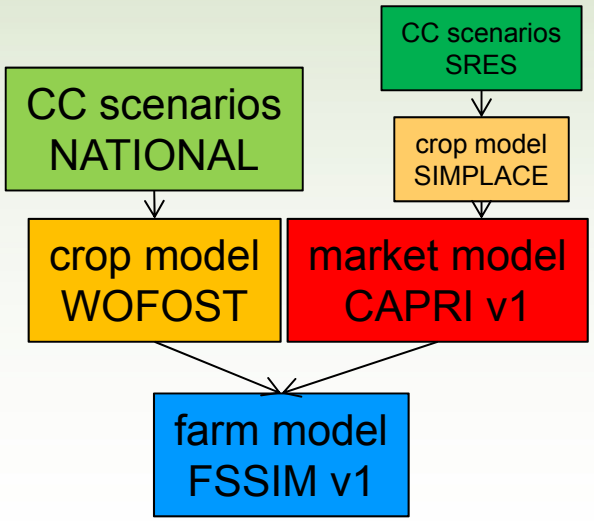
Comparing studies: yields & prices

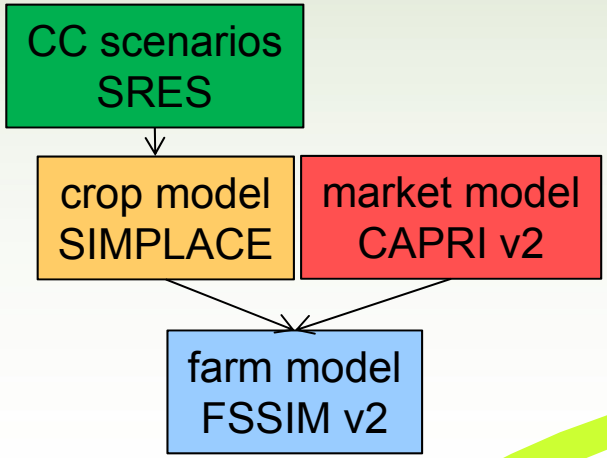


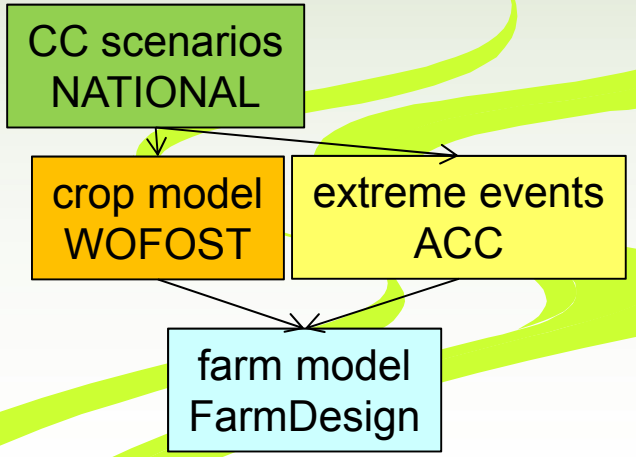
- Kanellopoulos et al. (WOFOST) >> Wolf et al. (SIMPLACE)
- Mandryk et al.: effect of extreme events potentially larger

Three farm models

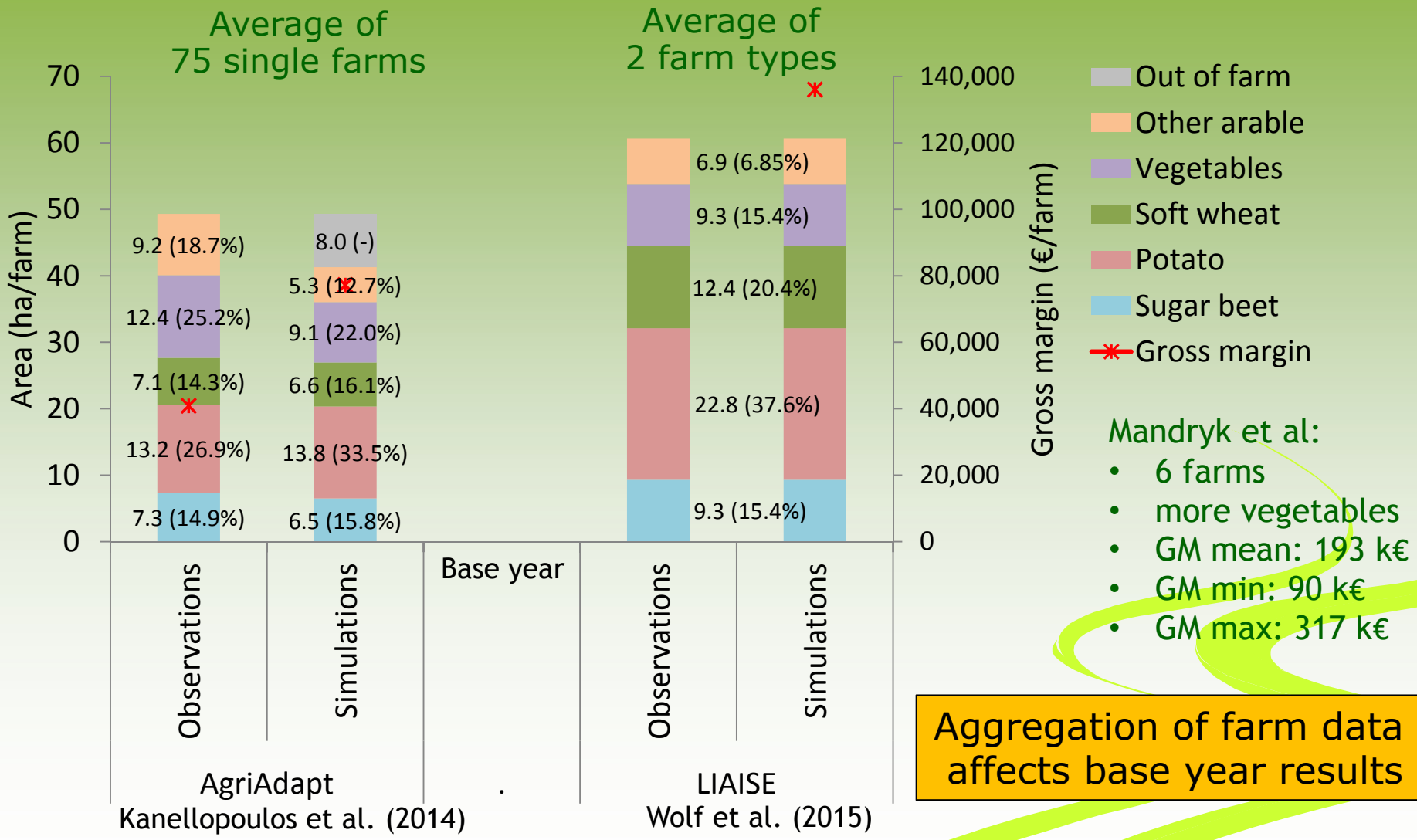
FSSIM v1	FSSIM v2	FarmDesign
Mathematical programming	Mathematical programming	Genetic Algorithms
Profit maximization	Profit maximization + PMP	Five objectives
Whole farm activities	Crop rotation activities	Crop activities
75 farms (FADN)	2 farm types (FADN)	6 farms (interviews)







Base year: farm plans & gross margins



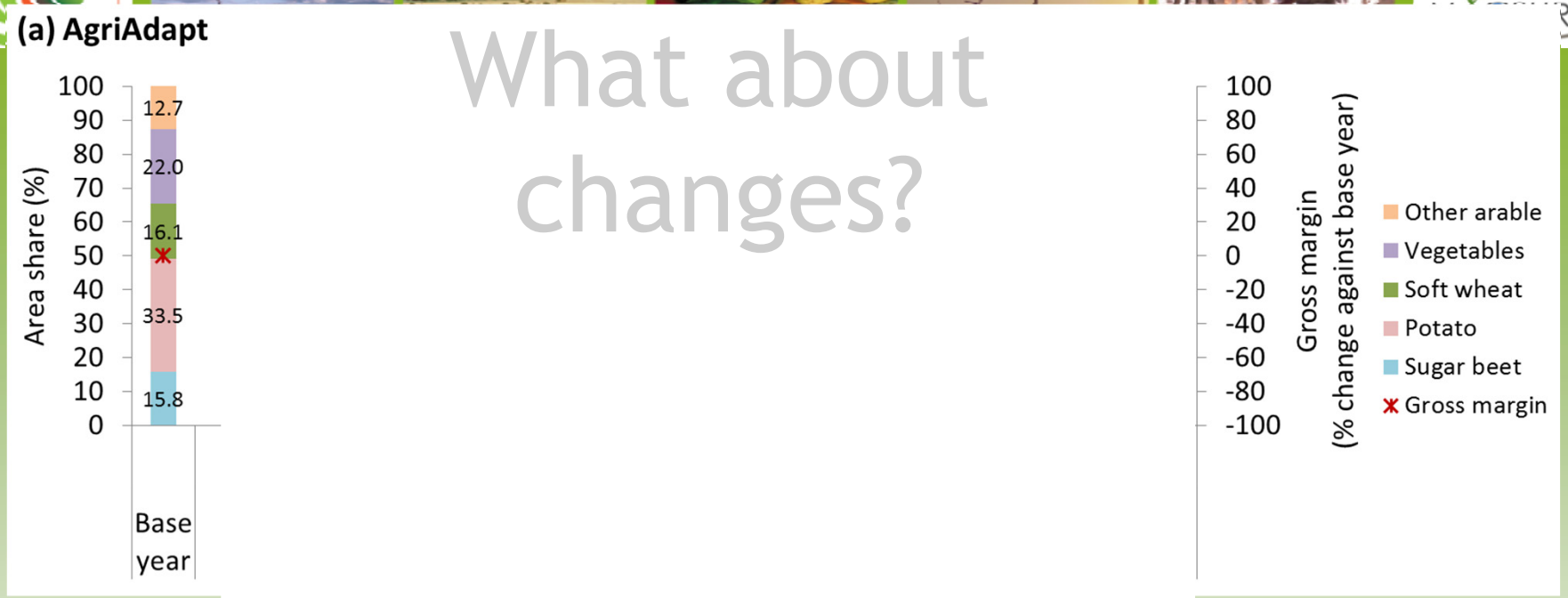
Mandryk et al:

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

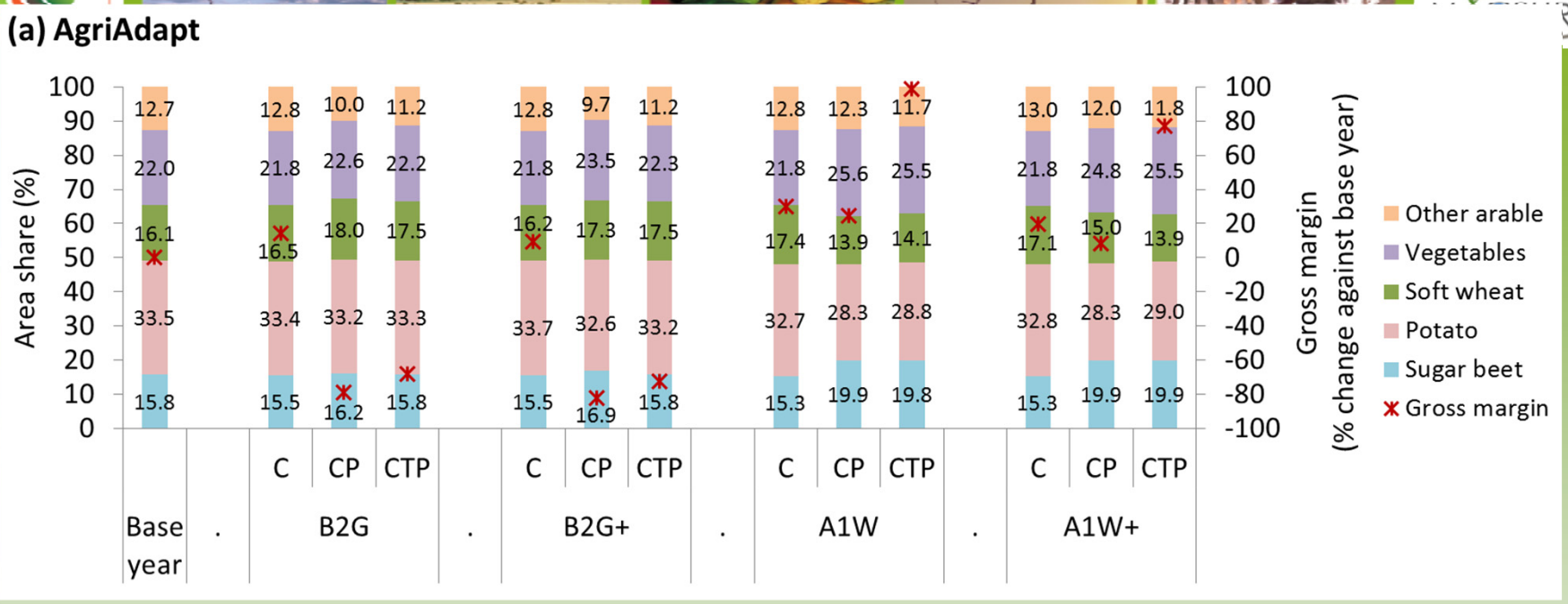
Aggregation of farm data affects base year results

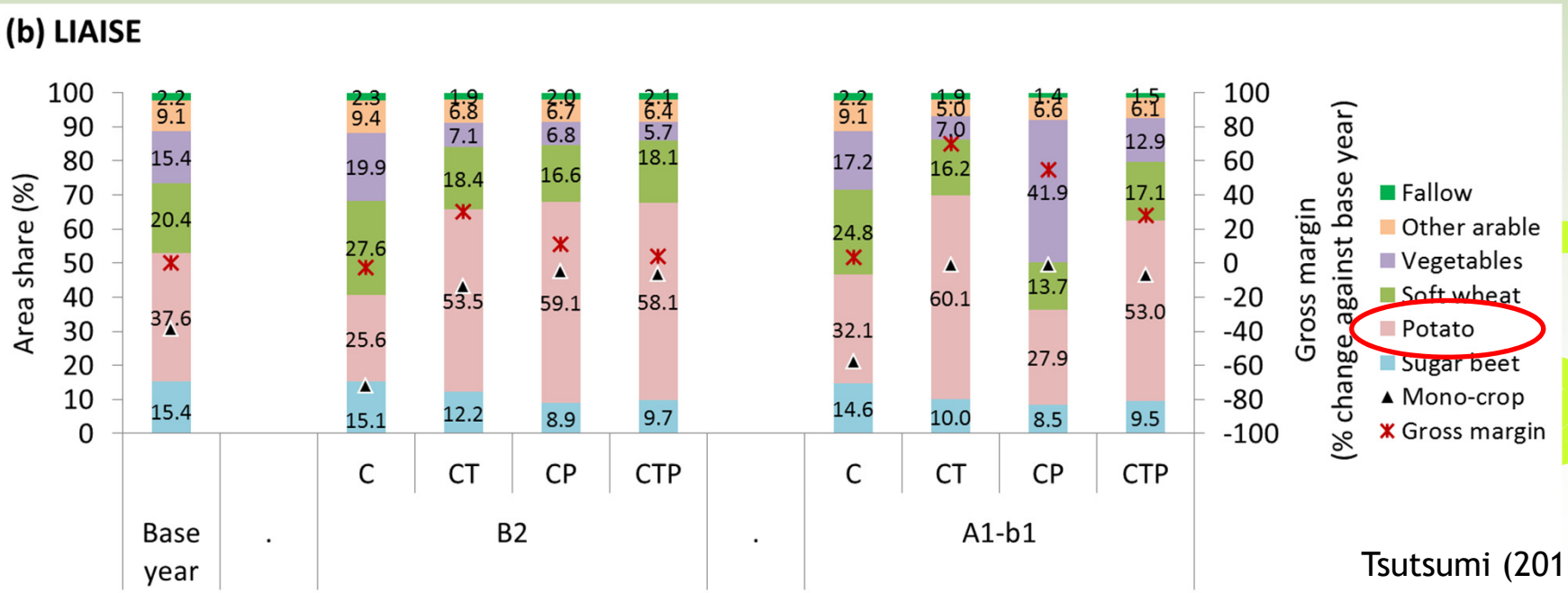
Tsutsumi (2015)

What about changes?



Tsutsumi (2015)





Tsutsumi (2015)

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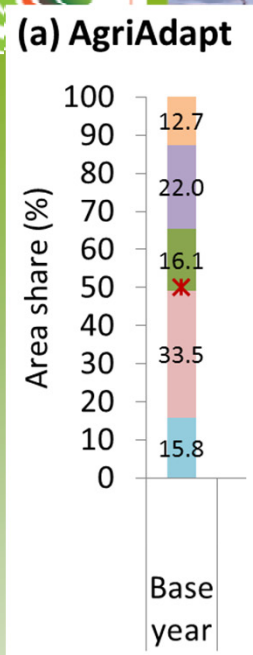
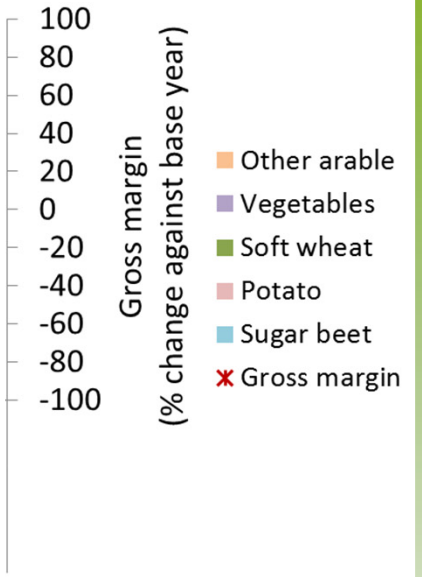
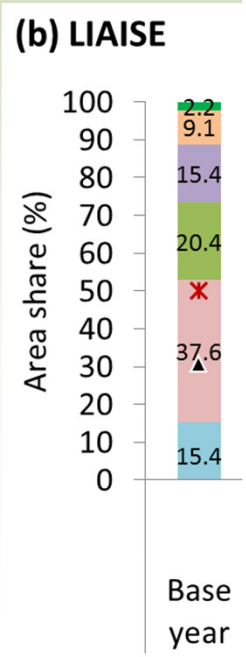
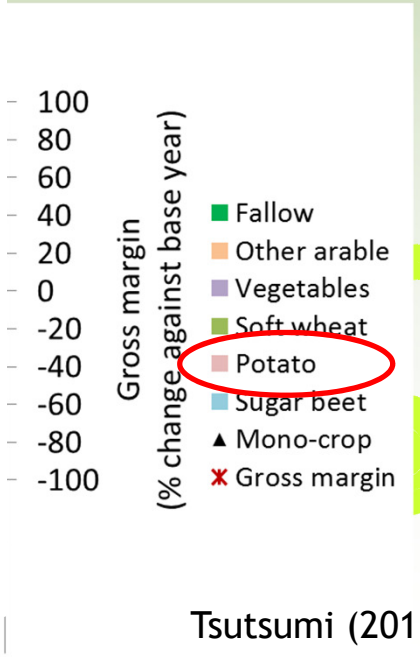


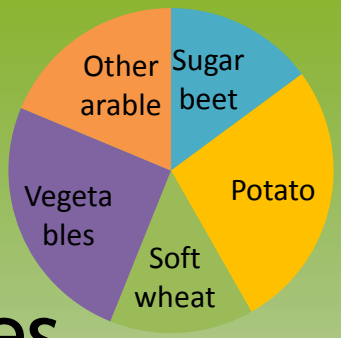






Tsutsumi (2015)

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

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

- **All changes**

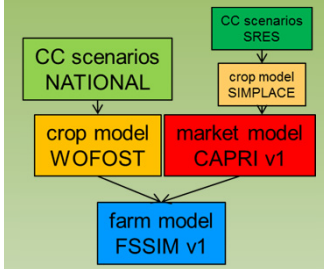
	up to -16%
	-38% to +26%
	-13% to +55%
	-63% to +16%

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

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

Kanellopoulos et al. (2014), Wolf et al. (2015)

Impacts on gross margins



Climate change:

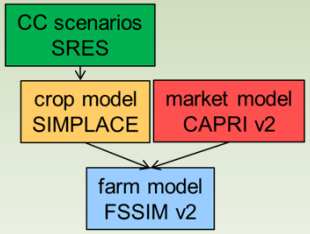
+14.2% to + 30.0%

higher yield changes by WOFOST

All changes:

-73% to + 99%

price & technology change

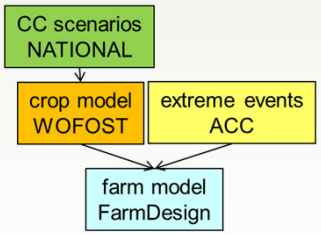


-2.7% to + 3.3%

lower yield changes by SIMPLACE

+ 3.8% to 28%

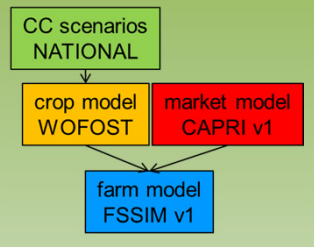
demand elasticities improved; price changes compensate technology change



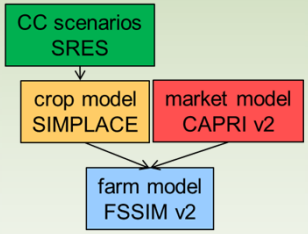
+ 15 % to + 43%

per farm plan, with adaptation to extreme events, no farm level adaptation: when policies not constraining, GM can increase more than yields

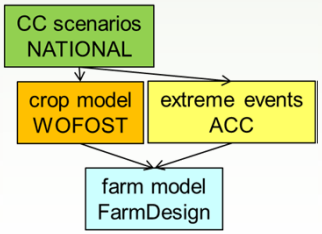
Impacts on environment



- 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



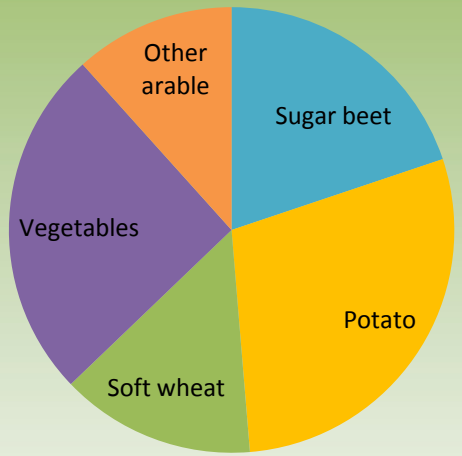
- Total N input
  - Changes together with yields & prices: -40% to +40%
- N2O emissions & N leaching
  - Similar as total N input, but smaller due to increase N use efficiency
- NH3 emissions
  - Similar as above, but smaller due to improved manure appl. techniques



- Soil Organic Matter
  - Farmers preferred farm plans: -8% to +42%

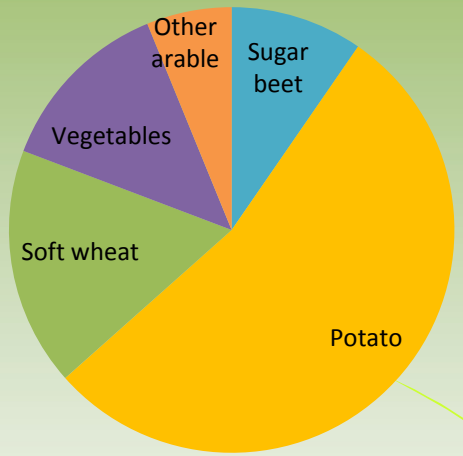
Flevoland in 2050?

Kanellopoulos et al. (2014)



Gross margin 99% up

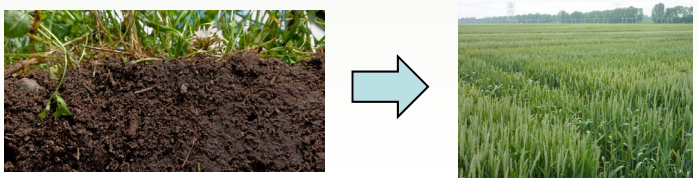
Wolf et al. (2015)



Gross margin 28% up

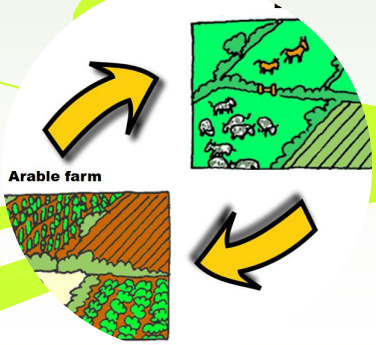
Mandryk et al. (2017)

SOM = objective more wheat



Nakasaka (2016)

Land exchange with dairy farms allows 21% more potato area

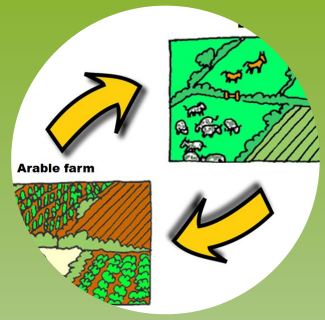


Main conclusions (1)

- 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

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