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Assessing the role of local level adaptation in limiting the economic impacts of more frequent extreme weather events in Dutch arable farming systems

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Agriculture in the Netherlands

- important economic sector
- high value per hectare, with a relatively large share of global agricultural production
- comprises different activities, e.g. milk and meat production, arable crops, vegetables, fruits and flowers



Climate change impacts in Dutch agriculture

- Gradual climate pattern changes are not expected to lead to a disruption of the agricultural sector
- In fact, potential yields of several crops are expected to increase, due to increase of temperature and CO_2 concentration
- However, potential decline on yield and product quality resulting from more frequent extreme weather events might severely undermine its relatively strong market position

Climate change impacts in Dutch agriculture

- Appropriate adaptation measures should be identified according to the main climate risks expected in a region
- Need to understand the interplay between local production capabilities, regional climatic changes and more general socio-economic conditions

Outline

We propose a spatially-explicit method using discounted time series of cash flows (EUR/ha), that combines local productivity factors, economic factors, crop-specific sensitivity to climatic extremes, and climate change scenarios:

1) Mapping the local economic performance of current arable farming systems

2) Mapping the local economic impacts resulting from damage on crop quality and productivity due to more frequent extreme weather events

Outline

We propose a spatially-explicit method using discounted time series of cash flows (EUR/ha), that combines local productivity factors, economic factors, crop-specific sensitivity to climatic extremes, and climate change scenarios:

3) Mapping the economic feasibility of adopting adaptation measures

4) Mapping the economic viability of arable farming systems under more frequent extreme weather events

Mapping local economic performance

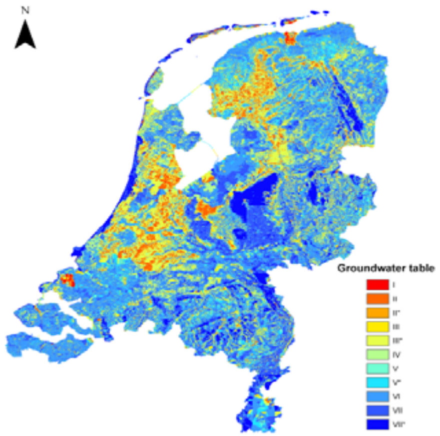
- Net Present Value (NPV):
  - standard method to appraise long-term projects, by measuring discounted time series of expected cash flows

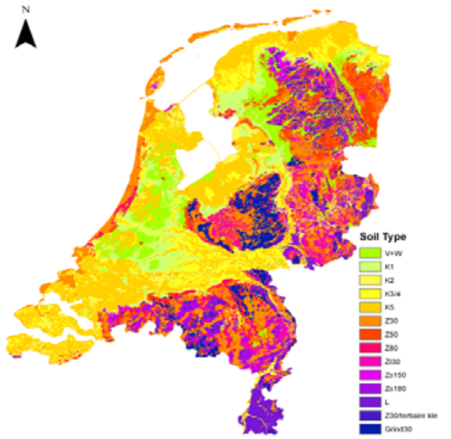
$$NPV_{c,i} = \sum_{t=y}^{n} \frac{B_{c,i,t} - C_{c,i,t}}{(1+r)^{t-y}}$$

- $B_{c,i,t}$ - benefits in year t (EUR/ha)
- $C_{c,i,t}$ - costs in year t (EUR/ha)
- r - discount rate
- y - initial year of the project

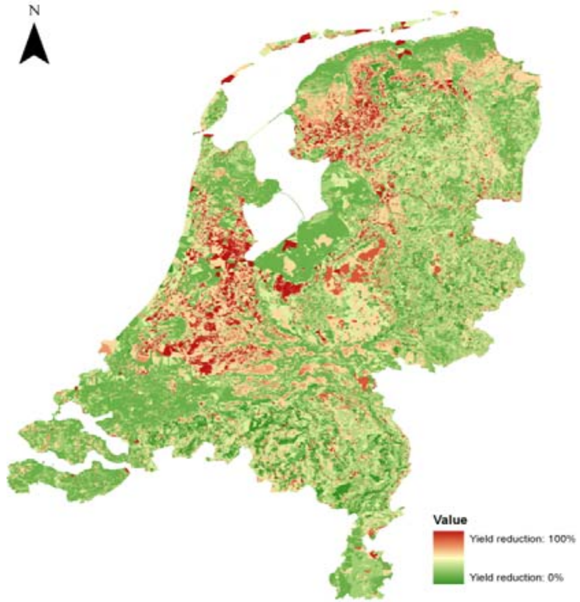
Mapping local economic performance

Local biophysical factors





Crop suitability maps



Locally attainable yields

Mapping local economic performance

Productivity and economic factors of arable farming crops

Crop	Soil type	Production costs (€/ha)	Maximum yield (ton/ha)	Market price (€/ton)	CAP subsidies (€/ha)
Ware potato	Clay	3342	49	112	-
	Sandy	3617	57	112	-
Seed potato	Clay	5112	37	261	-
	Sandy	4230	33	261	-
Starch potato	Clay / Sandy	2472	45	45	410
Sugarbeet	Clay	1927	81	43	270
	Sandy	2001	78	43	270
Barley, winter	Clay	1295	6,5	179	446
	Sandy	1261	6,5	179	446
Barley, summer	Clay	1119	6,6	179	446
	Sandy	1106	6,6	179	446
Wheat, winter	Clay	1563	9,6	174	446
	Sandy	1315	7,8	174	446
Wheat, summer	Clay	1212	7,1	174	446
	Sandy	1172	6,6	174	446
Onion	Clay / Sandy	3091	60	101	-

adapted from Van der Hilst et al., 2010

Mapping local economic performance

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Mapping local economic performance

Examples of regional crop rotation shares in arable farming systems

Region	Bouwhoek en Hogeland		Veenkolonien en Oldambt		Oostelijk Veehouderijgebied	
Soil type	Clay	Sandy	Clay	Sandy	Clay	Sandy
Ware potato	3%	0%	2%	3%	10%	14%
Seed potato	31%	82%	4%	2%	6%	7%
Starch potato	0%	0%	3%	47%	1%	31%
Sugarbeet	13%	4%	9%	21%	16%	16%
Barley,winter	1%	0%	1%	0%	7%	2%
Barley, summer	5%	14%	1%	16%	6%	14%
Wheat, winter	40%	0%	76%	5%	47%	10%
Wheat, summer	3%	0%	3%	6%	4%	5%
Onion	3%	0%	1%	0%	2%	0%
Fallow	1%	0%	0%	0%	1%	1%

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Mapping local economic performance

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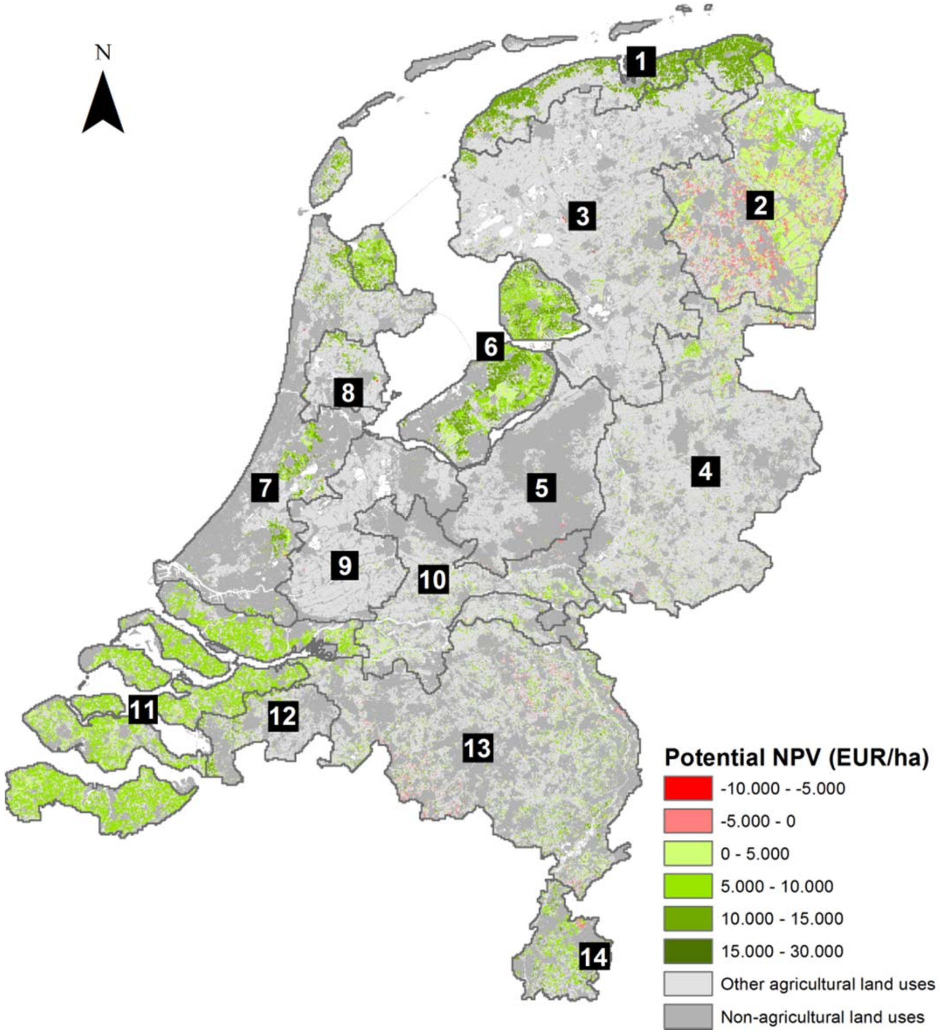
Fallow	1%	0%	0%	0%	1%	1%

adapted from Diogo et al., 2015

Mapping local economic performance



Mapping local economic impacts

Agro-climate calendar for selected climate factors and crops

Climate factor	Crop	Impact on crop	Vulnerable period	Economic loss per event (%)
High intensity rainfall	Potatoes (all varieties)	Rotting of the tubers	May-September	25-75
Warm and wet	Potatoes (all varieties)	Erwinia spp. infection	July-September	10-50
	Onion	Fungi infection	July-August	50-60
Heat wave	Potatoes (all varieties)	Second-growth	July-September	25-75
Long drought	Onion	Growth rate reduction	June-July	30-40
	Wheat	Yield decrease	June-August	10-50
Warm winter	Potatoes (all varieties)	Rotting of tubers and early sprouting	December-March	25-75
	Sugarbeet	Sugar content loss	December-March	10-25

adapted from Schaap et al., 2013

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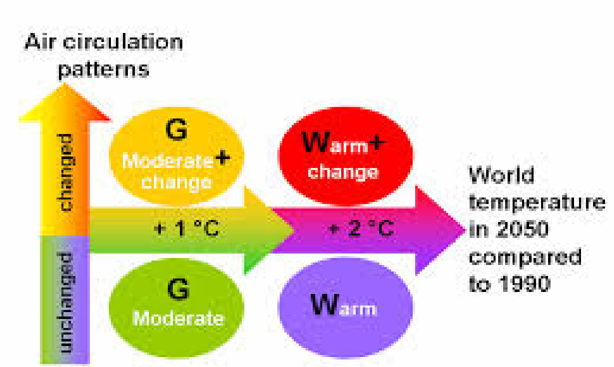
adapted from Schaap et al., 2013

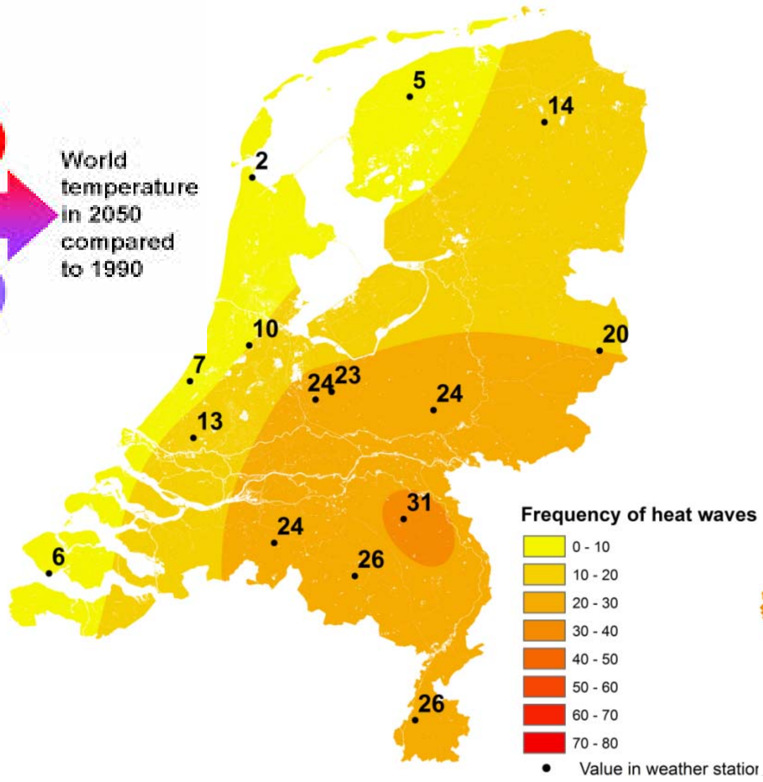
Mapping local economic impacts

Heat wave frequency in 30-years period, during the months in which potatoes are vulnerable

KNMI climate scenarios



G2050



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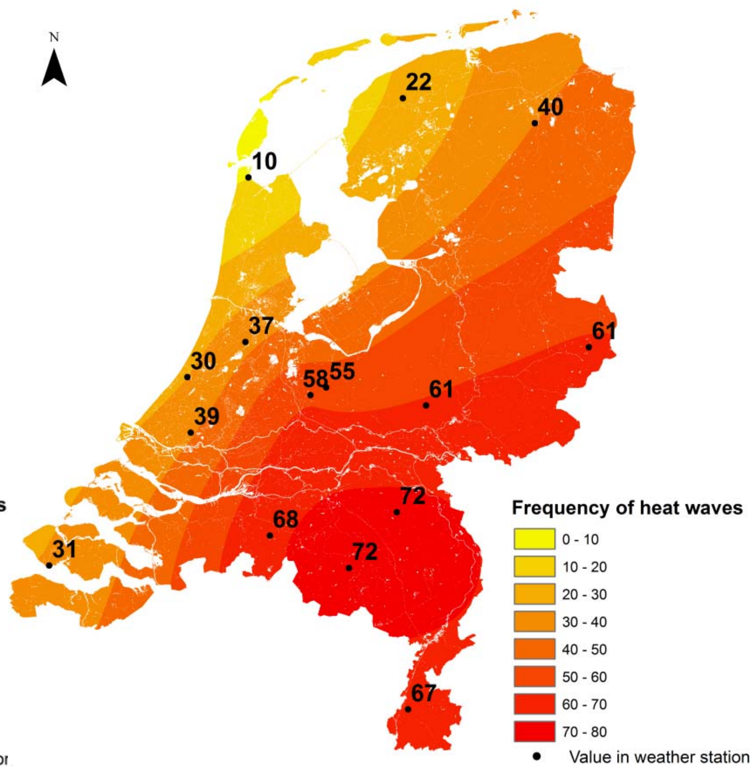
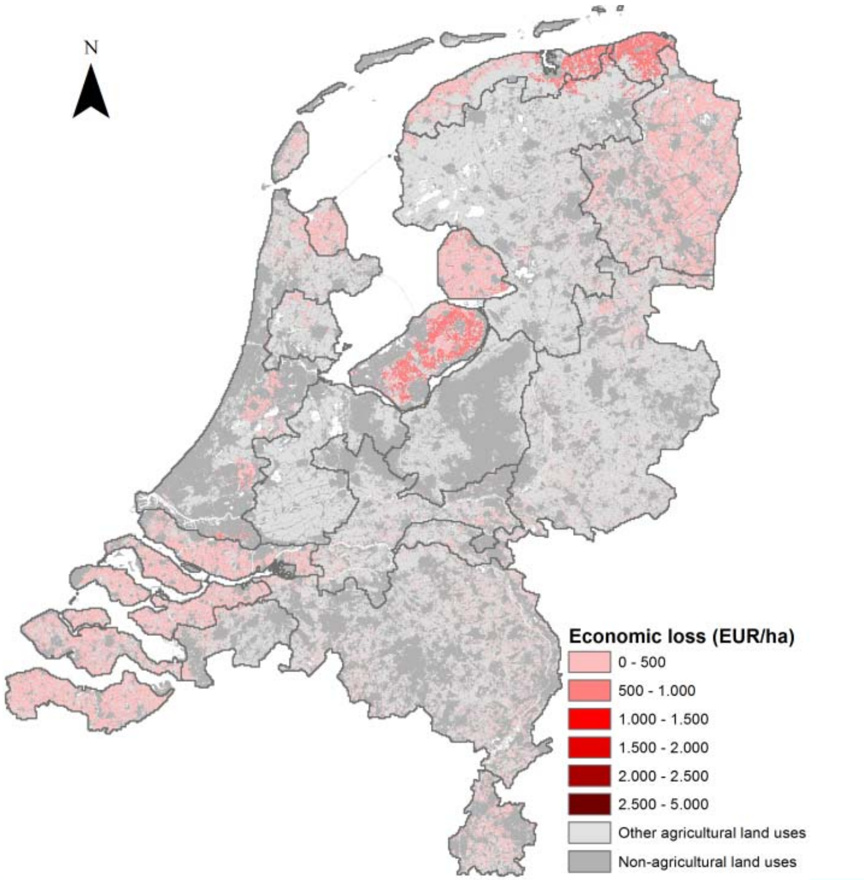


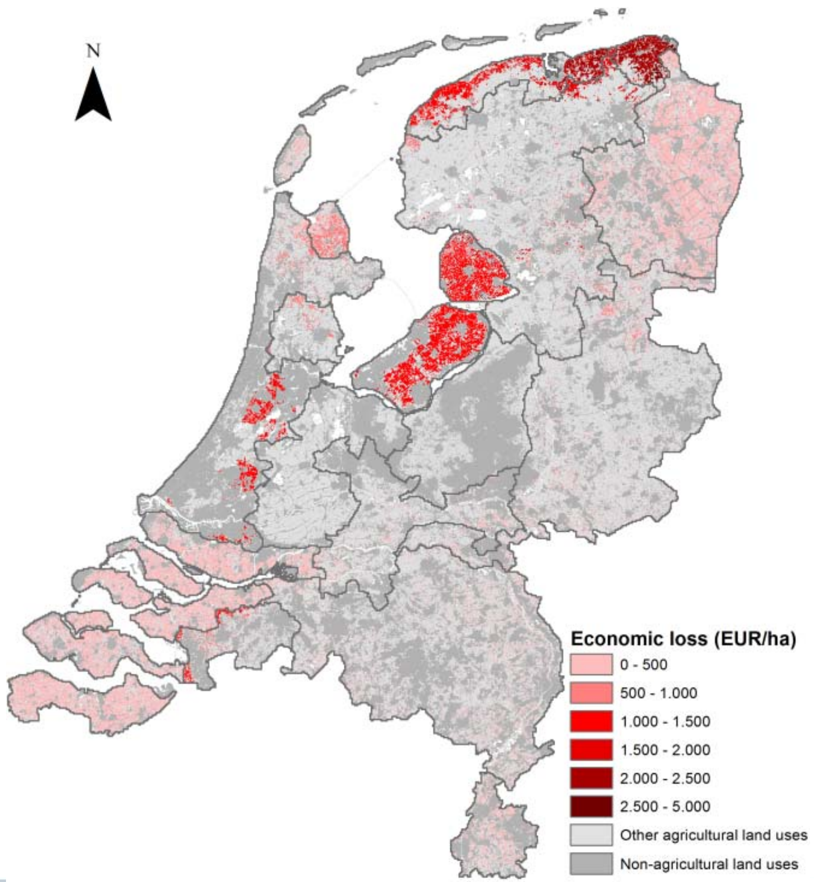
Mapping local economic impacts

Average annual economic loss resulting from the damage of heat waves on seed potato

G2050, high impact



W+2050, high impact



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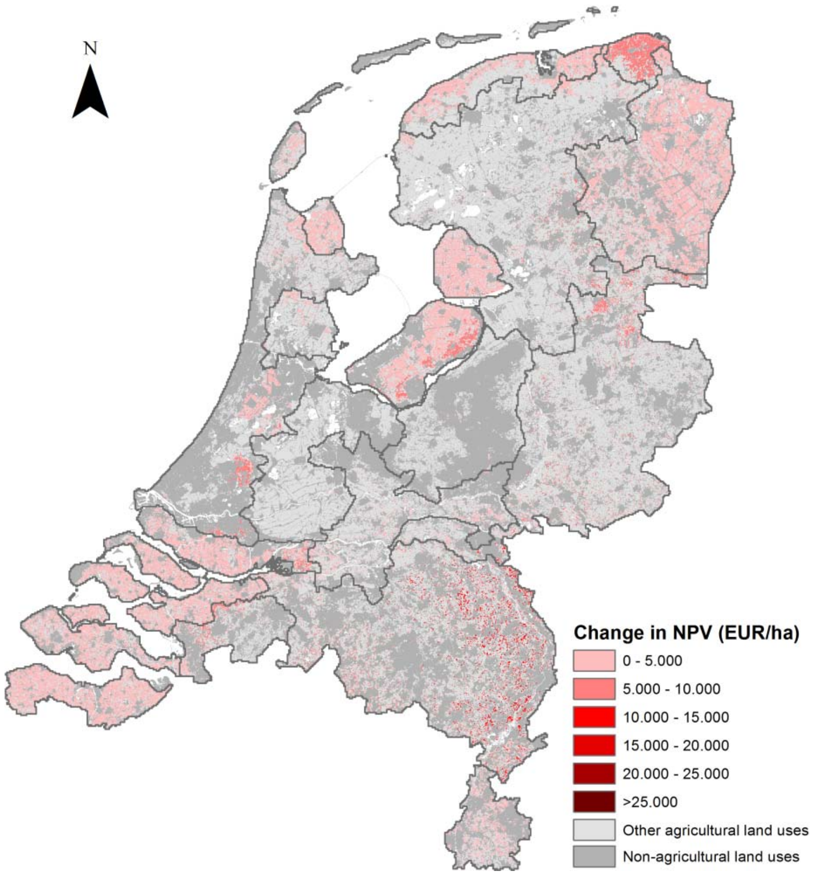
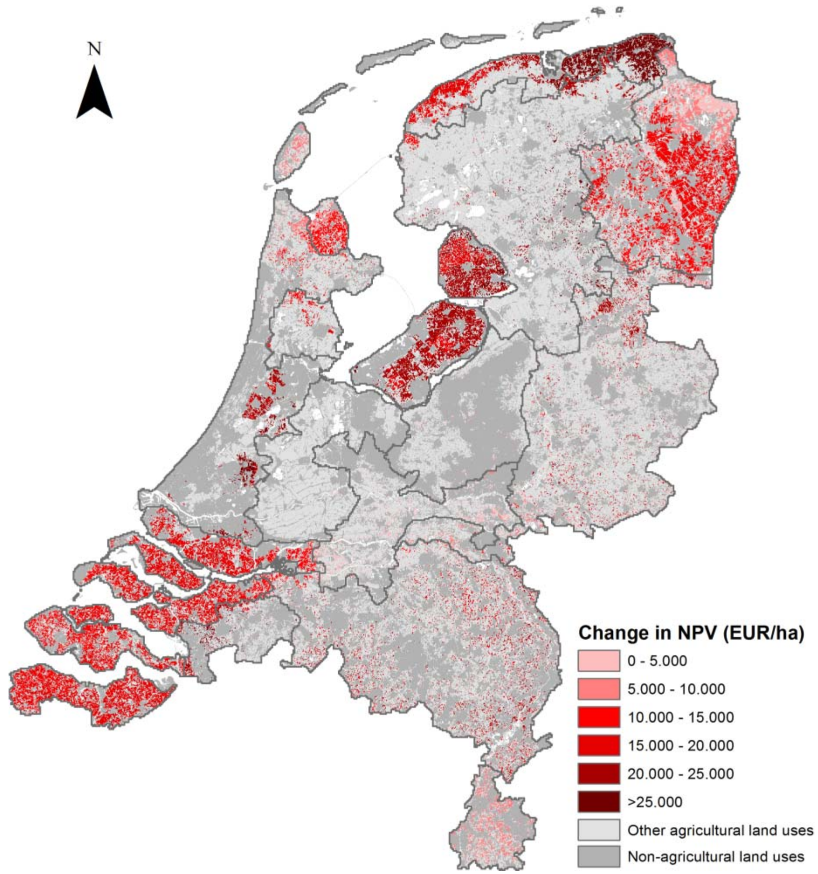
Mapping local economic impacts

Decrease in NPV due to increased frequency of heat wave events

G2050, high impact



W+2050, high impact



Mapping feasibility of adopting local adaptation measures

Portfolio of adaptation measures

Climate factor	Crop	Adaptation measure	Effectiveness (%)	Annual operational costs (€/ha)	Investment costs in the 1st year (€/ha)
High intensity rainfall	Potatoes (all varieties)	Increase permeability of subsoil	10	600	-
		Increase ability for surface drainage	75	150	-
		Intensify drainage	90	150	1500
Wet and warm	Potatoes (all varieties)	Optimise nutrient management	50	250	-
	Onion	Chemical protection	90	750	10000
		UV-light protection	90	750	30000
Heat wave	Potatoes (all varieties)	Plant and harvest earlier	25	-	-
		Cooling by drip irrigation	90	1000	-
		Optimise crop cover	75	250	-
Long drought	Onion	Irrigation	90	300	15000
		Re-sowing	50	750	-
		High density sowing	10	300	-
	Wheat	Increase the water holding capacity of the soil	10	300	-
Warm winter	Potatoes (all varieties)	Air conditioning during storage	90	150	3000
		Sprouting control	50	150	-
	Sugarbeet	Mechanical ventilation of the heap	50	150	5000

adapted from Schaap et al., 2013

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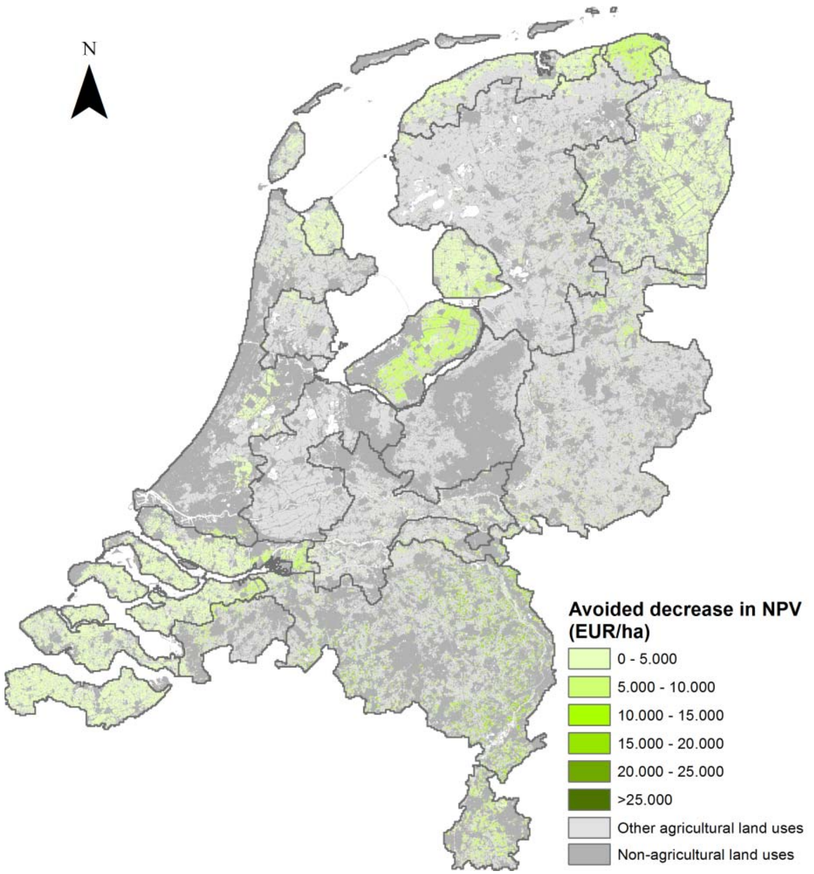
adapted from Schaap et al., 2013

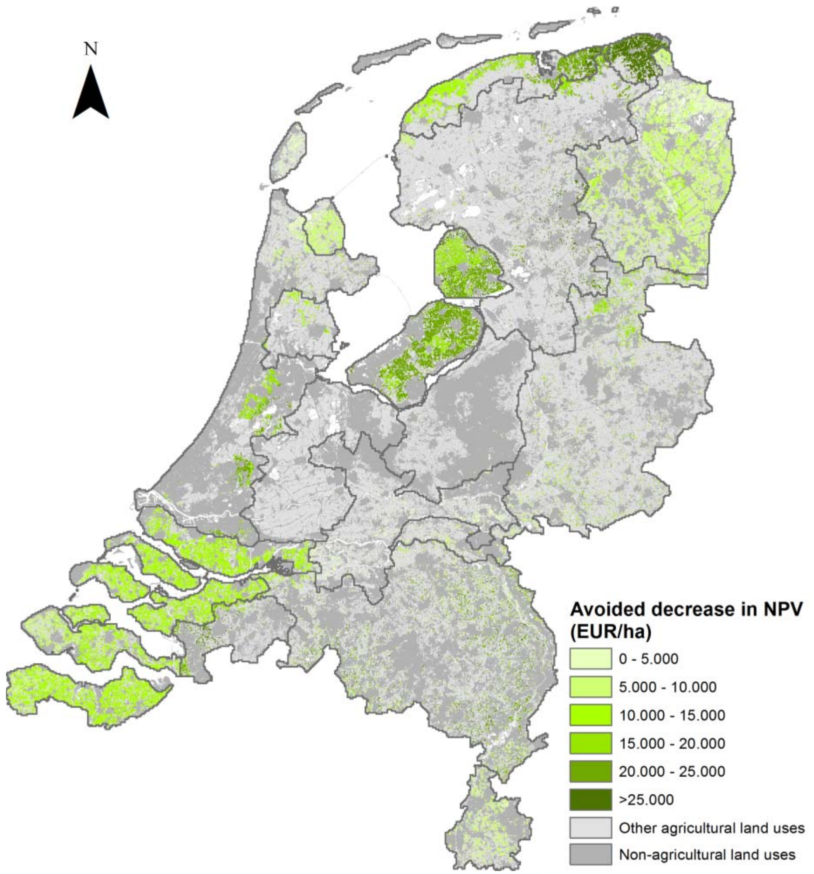
Mapping feasibility of adopting local adaptation measures

Avoided decrease in NPV due to adoption of adaptation measures

G2050, high impact



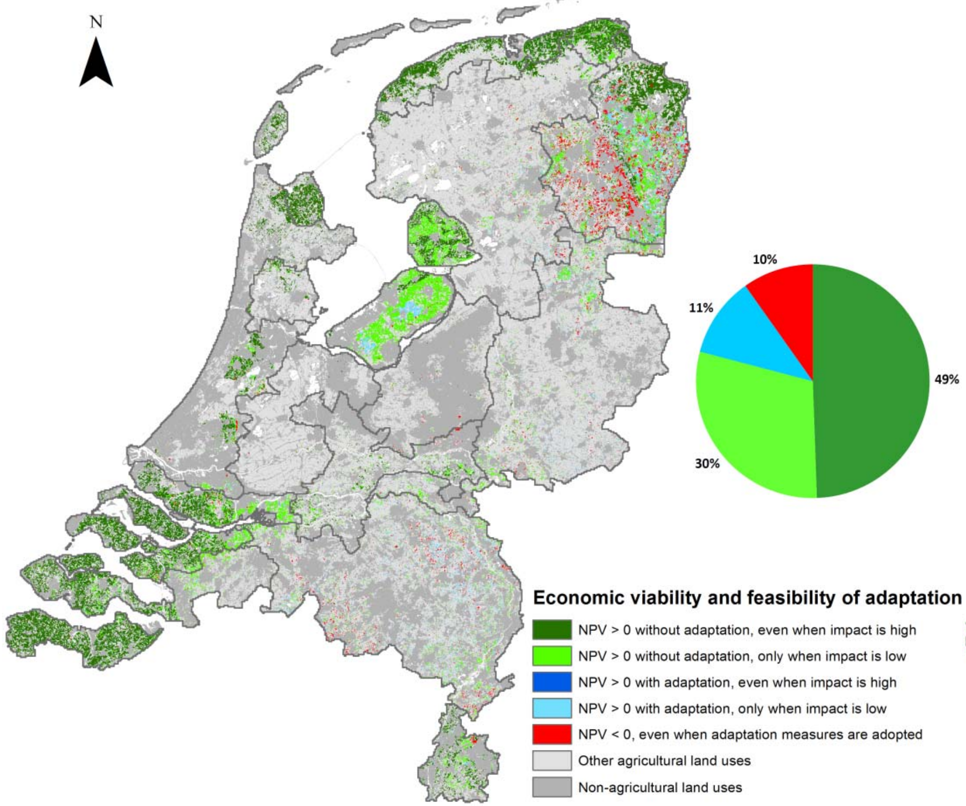
W+2050, high impact



Mapping economic viability of arable farming systems

Under more frequent heat waves

G2050



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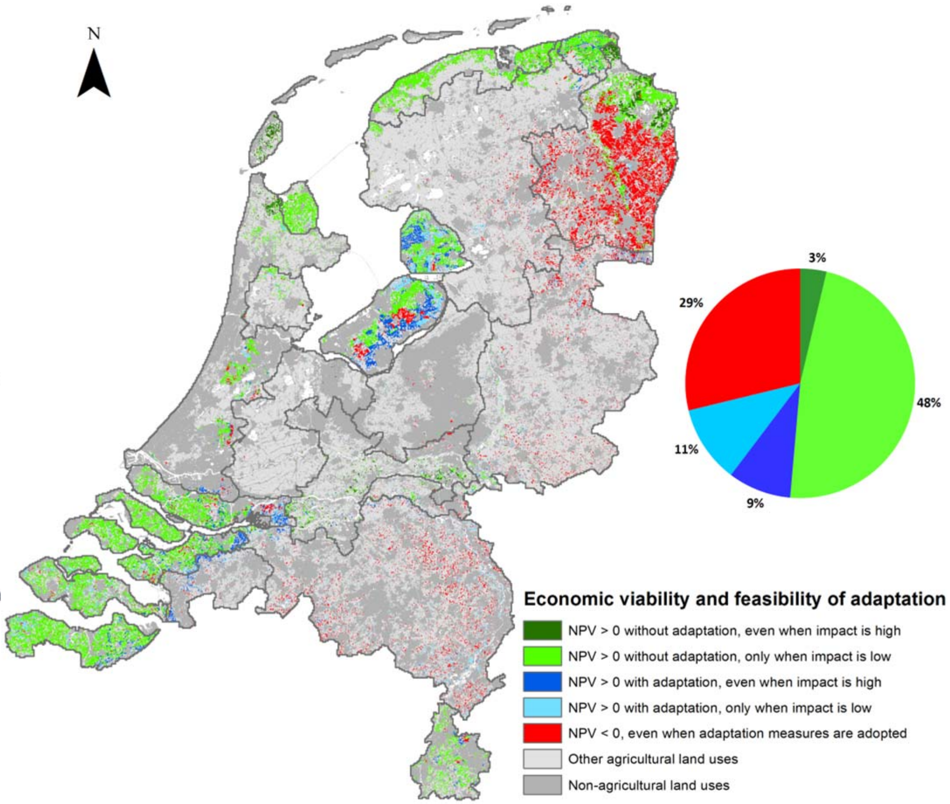
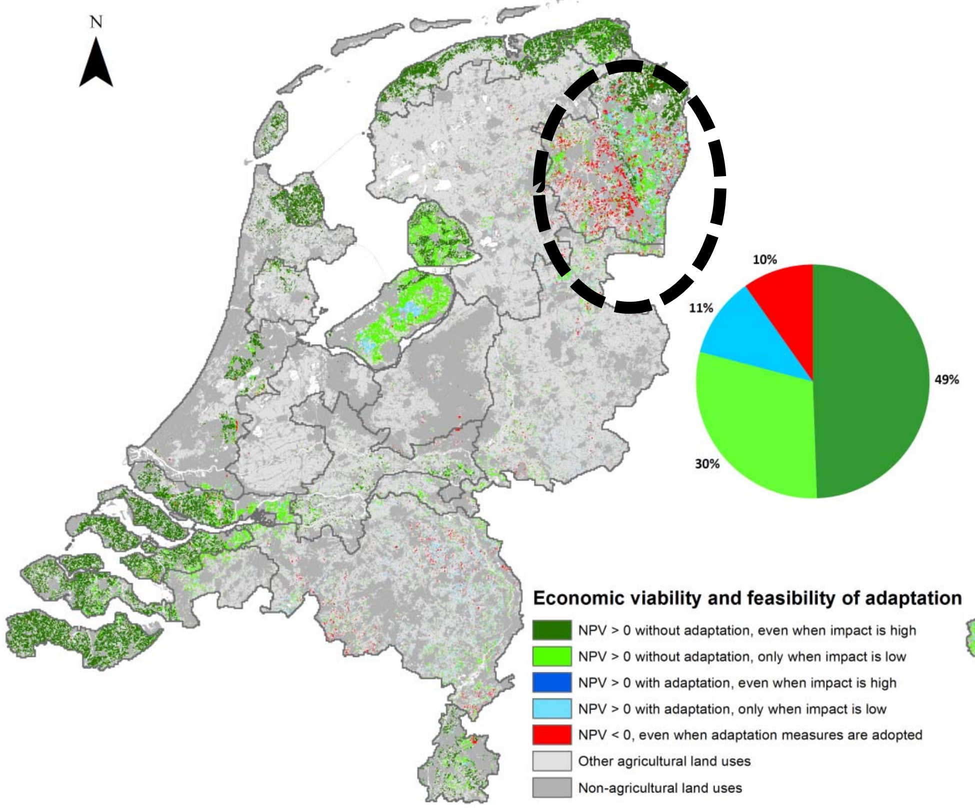


Mapping economic viability of arable farming systems

Under more frequent heat waves

G2050



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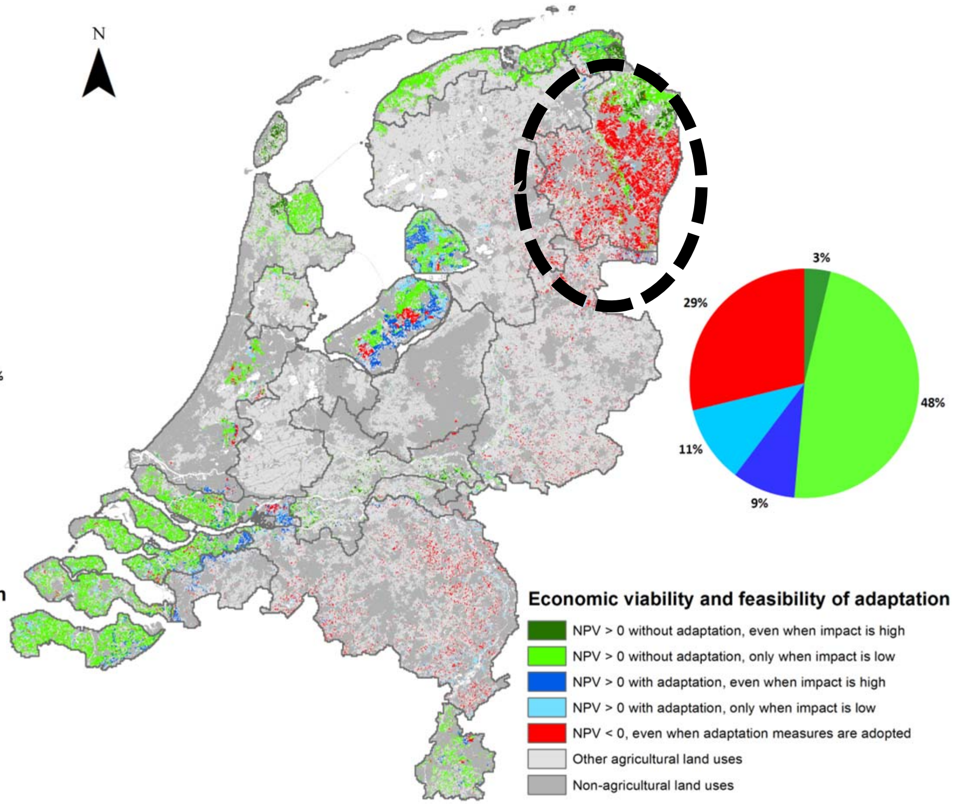

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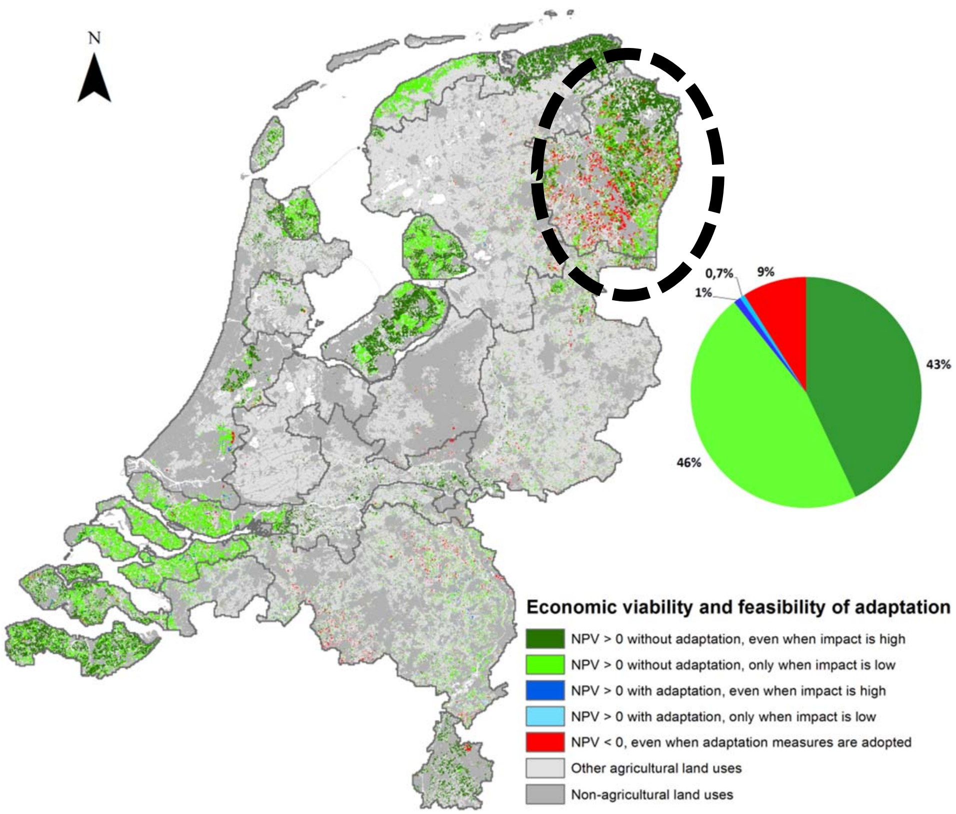
Mapping economic viability of arable farming systems

Under more frequent <u>high intensity rainfall events</u>

G2050



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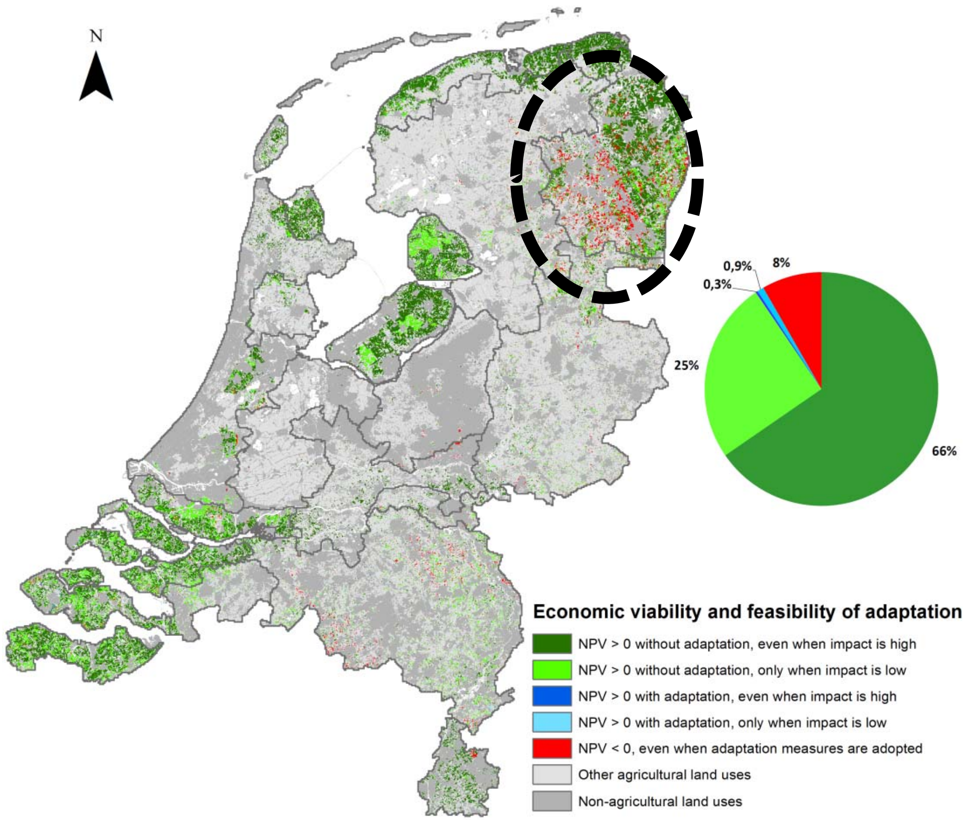
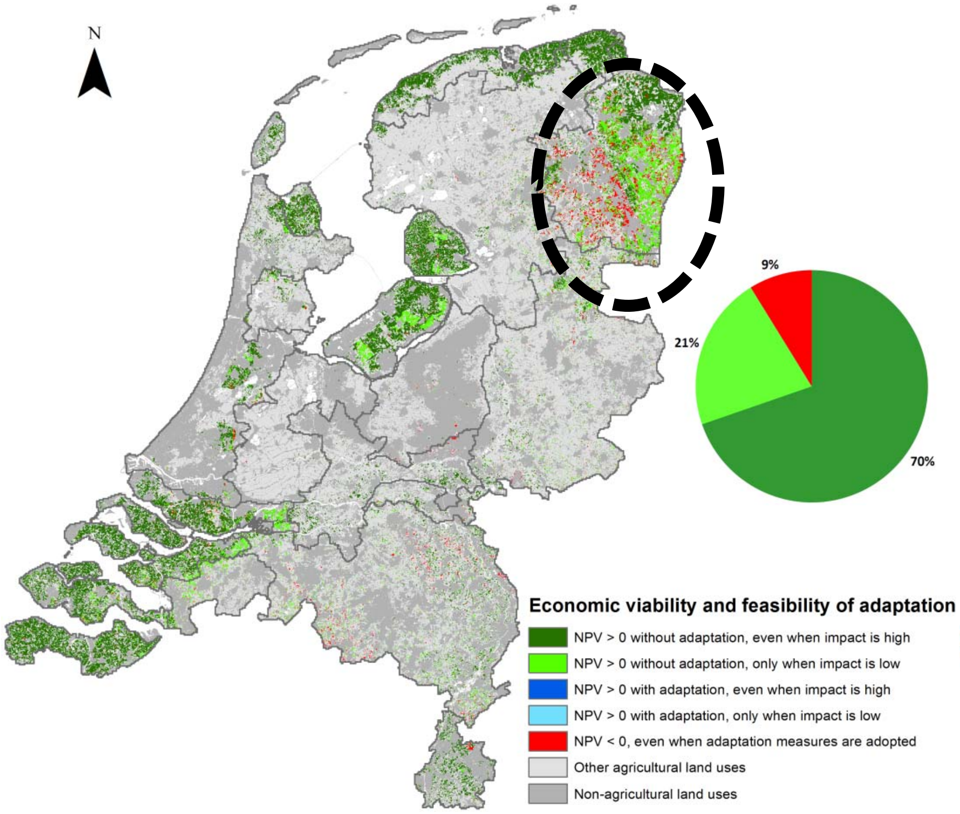


Mapping economic viability of arable farming systems

Under more frequent <u>warm and wet conditions</u>

G2050



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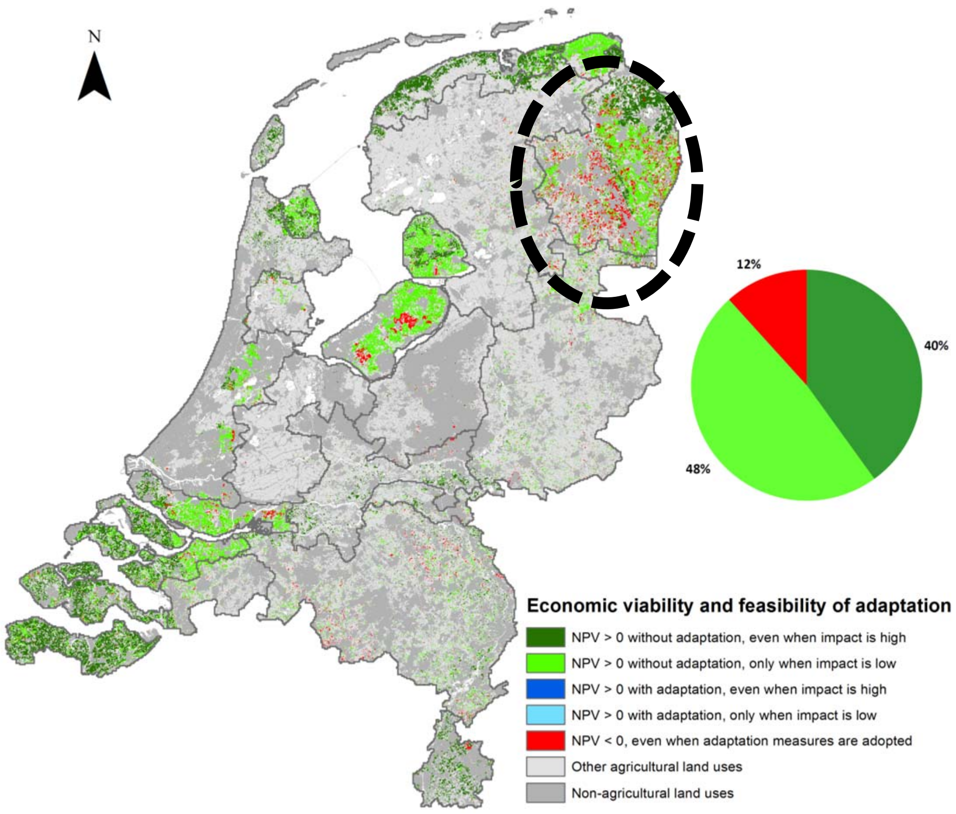
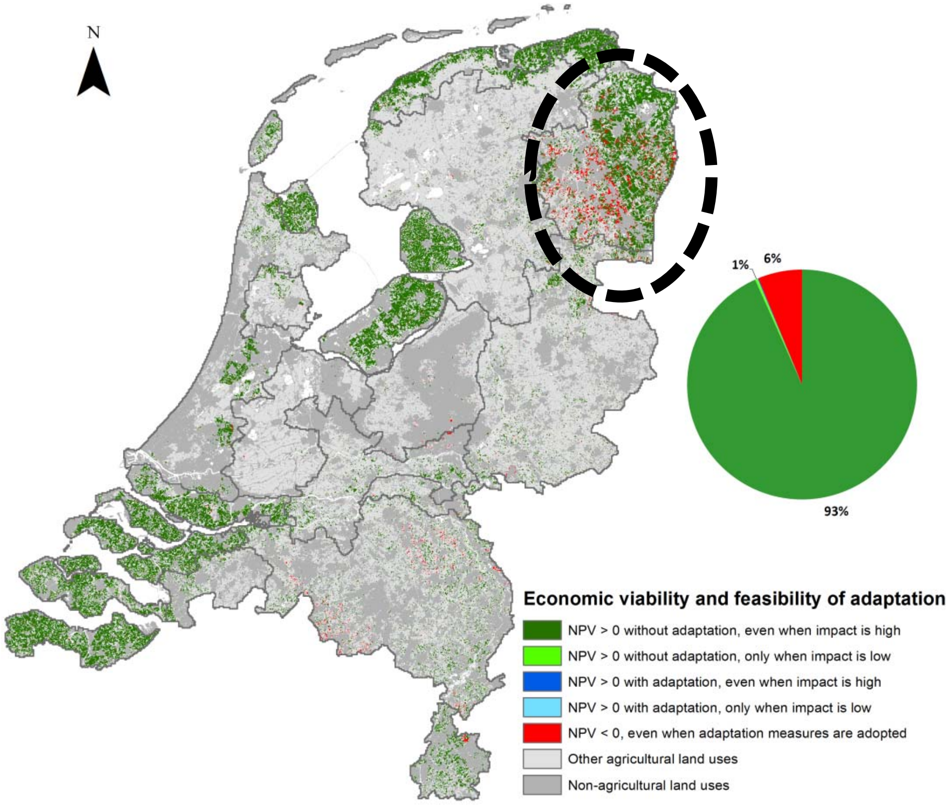


Mapping economic viability of arable farming systems

Under more frequent long droughts

G2050



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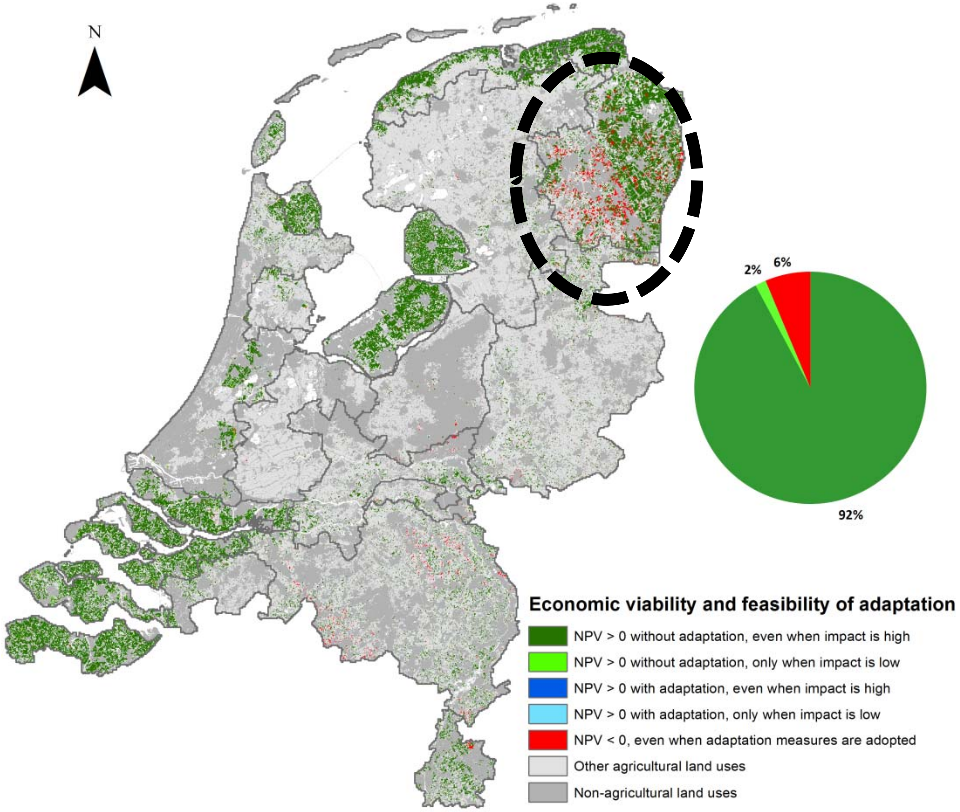

Mapping economic viability of arable farming systems

Under more frequent <u>warm winters</u>

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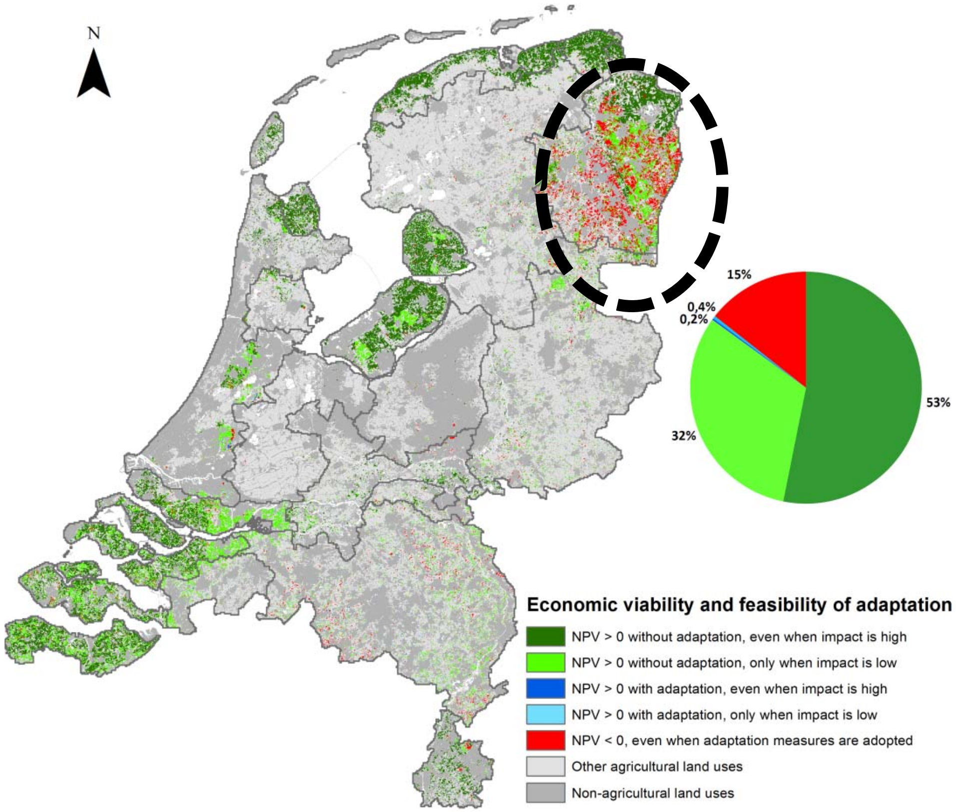

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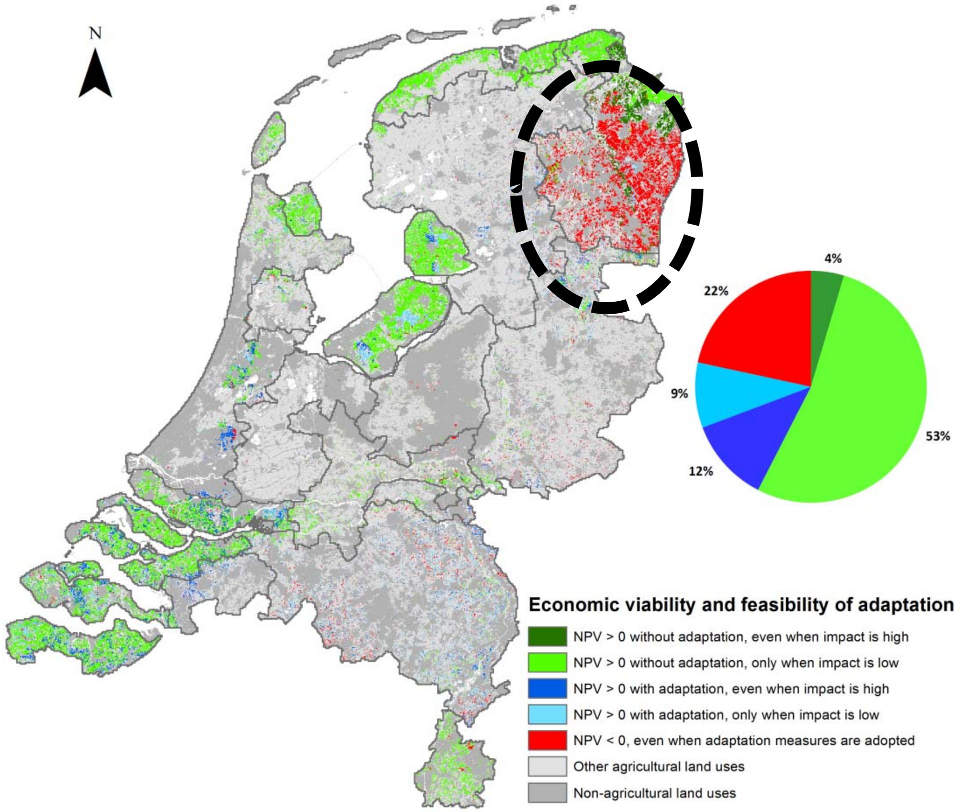
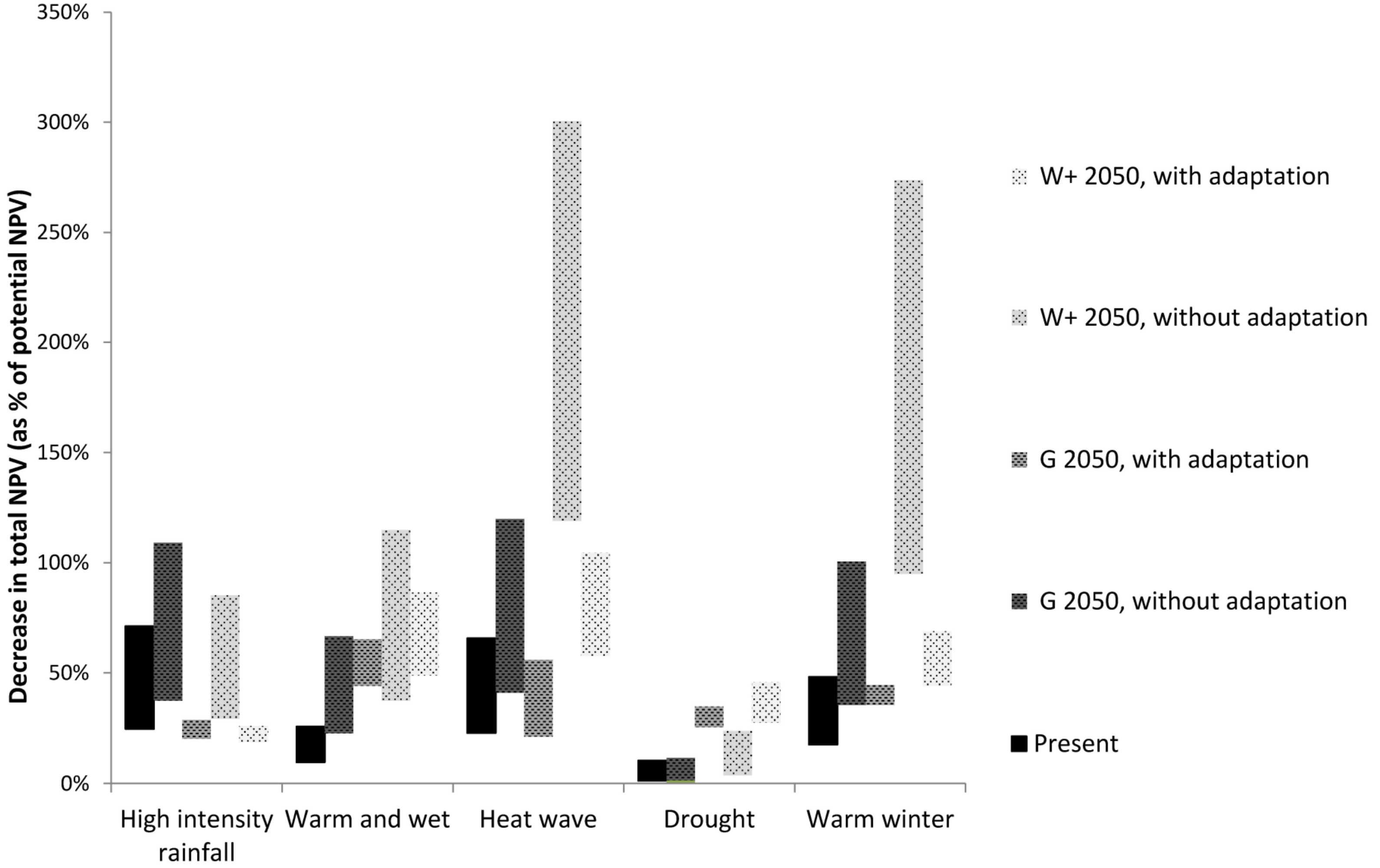


Mapping economic viability of arable farming systems



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Main findings

- expected frequency increase might pose serious threats to the future economic viability of arable farming systems in the Netherlands, particularly heat waves, warm winters and high intensity rainfall

- despite the high uncertainty on the exact magnitude of the impacts, for most extreme weather events the adoption of adaptation measures seems to be a no-regret strategy, since they help largely reducing both the economic impacts and their magnitude uncertainty

Main findings

- considerable differences were found between regions in terms of vulnerability to the considered climate factors

- some regions were shown to be consistently very vulnerable or very resilient to all climate factors, irrespective of the considered scenario

- the interplay between economic factors and management decisions (e.g. crop specialisation) appears to play a decisive role in the economic viability of agricultural systems under the pressure of more frequent climatic extremes

Conclusions

The proposed method allows to:

- assess the magnitude order of local economic impacts resulting from more frequent climatic extremes, while taking into account the spatial variability of specific local features that are relevant for agricultural systems

- identify and select, simultaneously for a relatively large area, the adaptation measures that are able to maximise local marginal benefits according to the specific characteristics of each location

Conclusions

The proposed method provides:

- plausible projections of the magnitude order of the economic impacts that can be exclusively assigned to the occurrence of climatic extremes, and the eventual ability of agricultural systems to cope with them through adaptation at the local level

- an overview of the most important region-specific threats and opportunities, thus improving communication on the main regional climate risks and contributing to prioritising adaptation

Thank you for your attention!

Questions?