Climate change and biomass production: a lucky match?

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Climate change and biomass production

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- Climate change
- Impact on crop growth
- Modelling
- Results
- Discussion & conclusion

Climate change and biomass production

Climate change

- Climate change of major importance
- Increasing demand for biomass
- Changes expected
  - Increasing crop area
  - Less favorable cultivation conditions
  - Impact of weather volatility (on prices)

Table 1 Expected effects of climate change for weather in Northwest Europe

	KNMI (period 2050 – 2100)	Hadley Centre (period 2020 – 2100)
Temperature	Increase of 1º–2º C in 2050 and a maximum of 4º C in 2100	Increase of 0.5º C in 2020 to 1.5º C in 2050 and 2.5 º C in 2100
Precipitation	Increase of 3%–6% in 2050 and 6%–12% in 2100	Decline by less than 40 mm per year to 2100 (5% change) or annual increase by 40–80 mm (5%–10% change) for 2050–2100
Season	Wetter winters (6%–12% in 2050 and a maximum 25% increase in 2100) and drier summers; largest increases in temperatures in wintertime.	Wetter winters (from 20mm per year to 40–80 mm per year in 2050 and thereafter), summers will be either drier (-40 mm per year or 5% less rain) to no change
Extreme precipitation	Increase of 10%–20% in 2050, and a maximum of 40% in 2100 in winter; increase of 1%–2% in 2050, a maximum of 4% in 2100 mainly in local and heavy showers (10%–20% higher intensity in 2050 and up to 40% in 2100 compared with 1990) in summer.	Little change in the distribution and frequency of precipitation in winter and summer
Storms	Chance and intensity of storms increase, but there is relatively great uncertainty	Not available

Source: Langeveld et al., 2003

Table SPM-2. Recent trends, assessment of human influence on the trend, and projections for extreme weather events for which there is an observed late 20th century trend. {Tables 3.7, 3.8, 9.4, Sections 3.8, 5.5, 9.7, 11.2-11.9}

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend [b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells / heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

Climate change and biomass production

Crop growth affected

- Double CO_2-concentrations
  - Yield increase 15-50 %
- Increased temperatures
  - Reduction of CO_2 effect to 10-30%
  - Increased spring growth
  - Early maturing, faster leaf ageing

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Crop growth affected

- Water use may remain at comparable levels
  - Reduction water use related to CO_2 increase
  - Increased transpiration and evapotranspiration
- Changes in dynamics of weather parameters
  - Risks of crop failure and loss of product quality

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Increasing extremes

- Three years of once in a 1250 yr events in Meuse area
- Precipitation in Netherlands: more water, same number of raindays (1901-2001)
- Temperature rise +1ºC leads to 10% increase of extremes
- UNEP: damage doubling every decade (going to 150 billion yr $^{-1}$)

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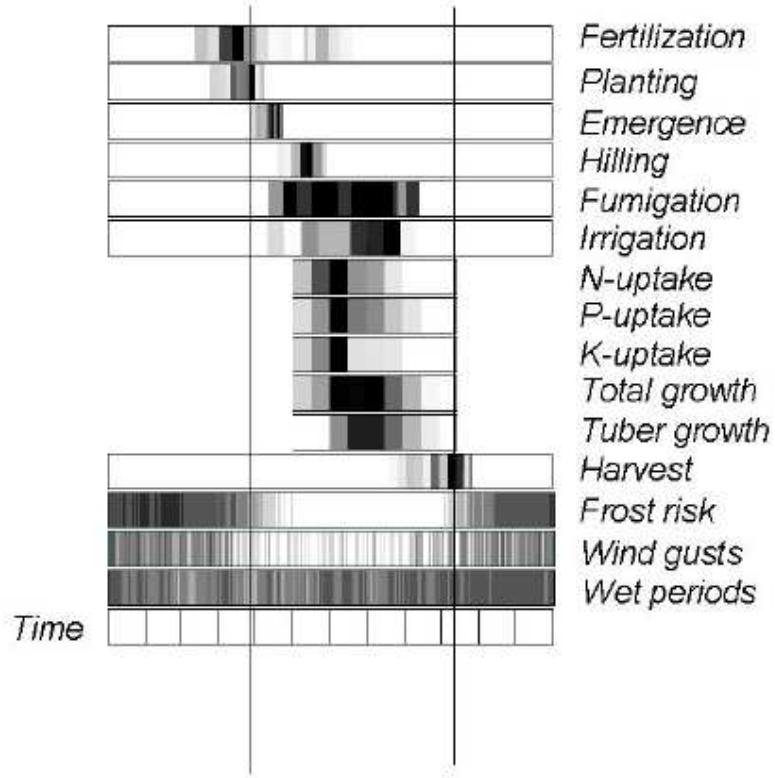
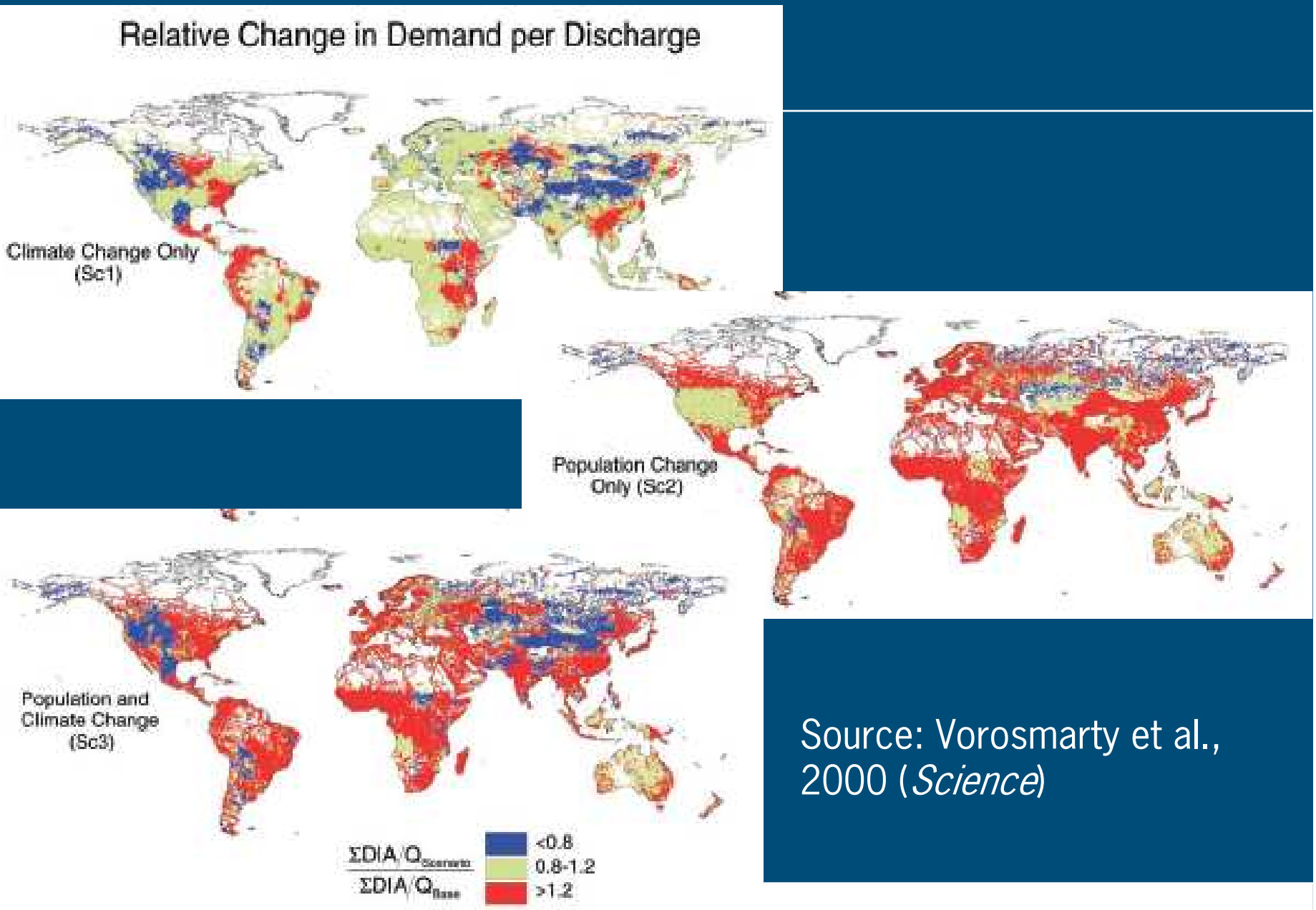


Figure 1 Timing of crop development, crop management and occurrence of frosts, extreme wind gusts and extreme precipitation of a potato crop in the North of the Netherlands. Grayscales indicate the relative frequency of the event (white: very rare, black: common). Time is depicted by twelve blocks, each block indicating a period of one month.

Source: Langeveld et al. (2003)



Source: Vorosmarty et al., 2000 (*Science*)

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*Table ES.2 Overview of uncertainties and their impact on biomass resource potentials**

Issue/effect	Importance	Impact on biomass potentials compared to	
Supply potential of biomass		*supply as estimated in recent studies*	*OECD baseline scenario in IMAGE*
Improvement agricultural management	***	↑↓	↑ 40-65%
Choice of crops	***	↓	↓ 5-60%
Food demands and human diet	***	↑↓	n/a
Use of degraded land	***	↑↓	↑ ca. 30-45%
Competition for water	***	↓	↓ 15-25%
Use of agricultural/forestry by-products	**	↑↓	n/a
Proceted area expansion	**	↓	↓10-25%
Water use efficiency	**	↑	n/a
Climate change	**	↑↓	n/a
Alternative protein chains	**	↑	n/a
Demand for biomaterials	*	↑↓	n/a
GHG balances of biomass chains	*	↑↓	n/a

Source: Dornburg et al. (2008)

Weather extremes and water scarcity

Table 4: Biofuels land and water, projections for 2030

	biofuel in billion liters	*main feedstock crop*	*area for biofuel crops million ha*	*% of total cropped area for biofuels [b]*	*crop ET for biofuels km3*	*% total crop ET for biofuels [c]*	*irrigation withdrawals for biofuel crops(km3)*	*% of total irrigation withdrawals for biofuels d*
USA, Canada	51.3	maize	14.1	9%	76.0	11%	36.8	20%
EU	23.0	rapeseed	14.6	28%	30.1	17%	0.5	1%
China	17.7	maize	7.8	4%	43.6	4%	35.1	7%
India	9.1	sugarcane	1.1	1%	21.6	3%	29.1	5%
S-Africa	1.8	sugarcane	0.2		3.9	12%	5.1	30%
Brazil	34.5	sugarcane	4.4	7%	86.3	14%	41.7	68%
Indonesia	0.8	sugarcane	0.1	0%	2.5	1%	3.9	7%
World	***141.2***		***42.2***	*3%*	***261.5***	*3%*	***178.4***	*5%*

Source: De Freiture et al., 2007

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Crop growth modelling

- Effects of climate change
- Systematic, controlled
- Interactions: G x E
- Assessment, scenarios

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Crop growth modelling

- Dynamic crop simulation model WOFOST
- Radition, temperature, water limitation, nitrogen
- Increased CO_2-effects
  - Maximum leaf assimilation rate, light response curve
  - Reduced transpiration
- Temperature, precipitation, evapotranspiration

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Crop management

- Winter wheat
- Standard management (120 kg N/ha)
- Poor, coarse sandy soil
- No limitations / N - H_2O limited
- Irrigation (0 / 60 mm)

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Weather files

- Data derived from Royal Meteorological Institute
- Temperature, precipitation, evaporation, wind
- 1976-1991 compared to double CO_2 (2020)
- De Kooy, Noord Holland
- Scenario: +1^{o}C, strong circulation (G+)

Climate change and biomass production

Table 1 Potential production

Yield	Production (t/ha)	Best 5 years	Worst 5 years
Average (t/ha)	9.1	11.1	6.9
Stdev (t/ha)	1.9	0.8	1.1
%	20.6	6.8	16.0
Worst / best (%)			62.4

Table 2 Nitrogen, water delimited production

Yield	Production (t/ha)	Best 5 years	Worst 5 years
Average (t/ha)	5.2	7.9	2.7
Stdev (t/ha)	2.3	1.4	0.8
%	44.5	17.8	30.6
Worst / best (%)			34.7

Climate change and biomass production

Table 2 Nitrogen, water delimited production

Yield	Production (t/ha)	Best 5 years	Worst 5 years
Average (t/ha)	5.2	7.9	2.7
Stdev (t/ha)	2.3	1.4	0.8
%	44.5	17.8	30.6
Worst / best (%)			34.7

Table 3 Nitrogen, water delimited production *with irrigation*

Yield	Production (t/ha)	Best 5 years	Worst 5 years
Average (t/ha)	6.9	9.3	4.7
Stdev (t/ha)	2.1	1.2	0.7
%	29.9	12.7	15.3
Worst / best (%)			51.0

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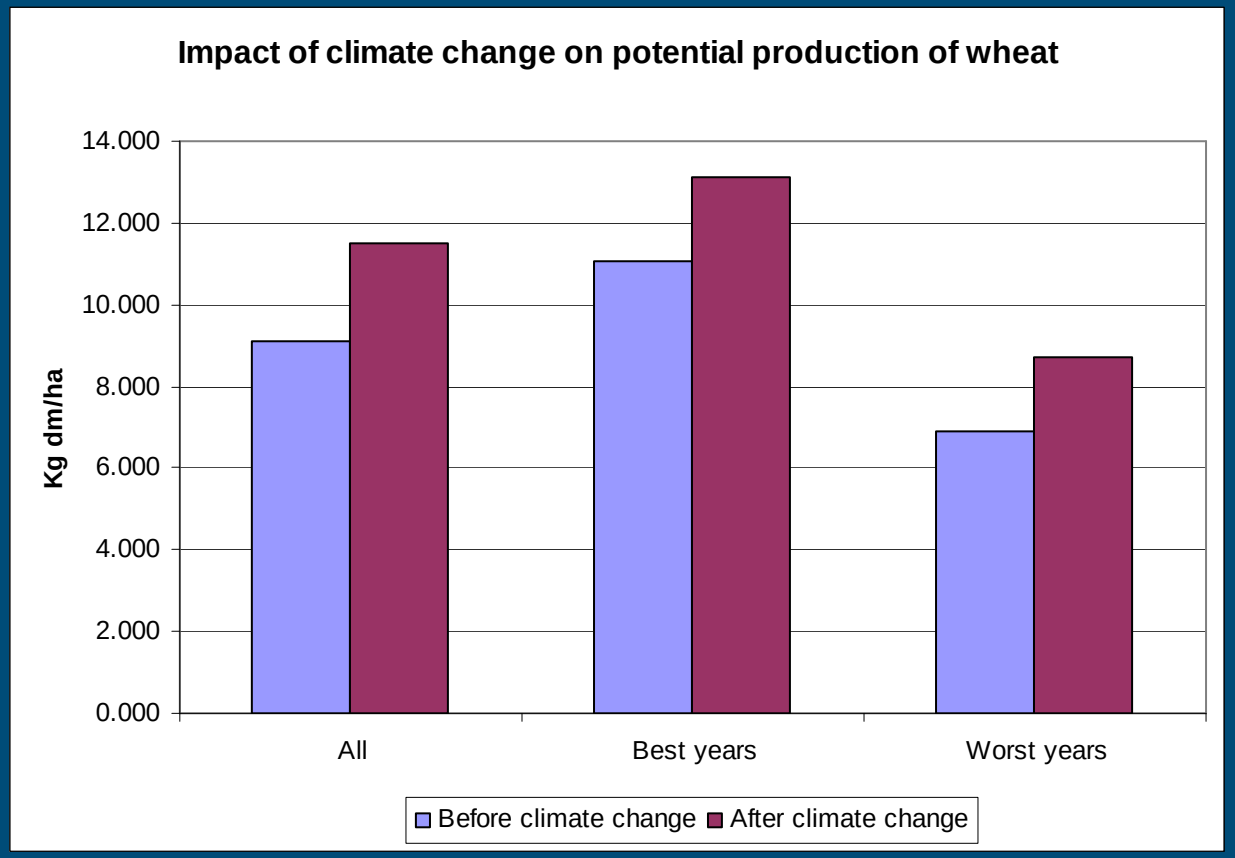

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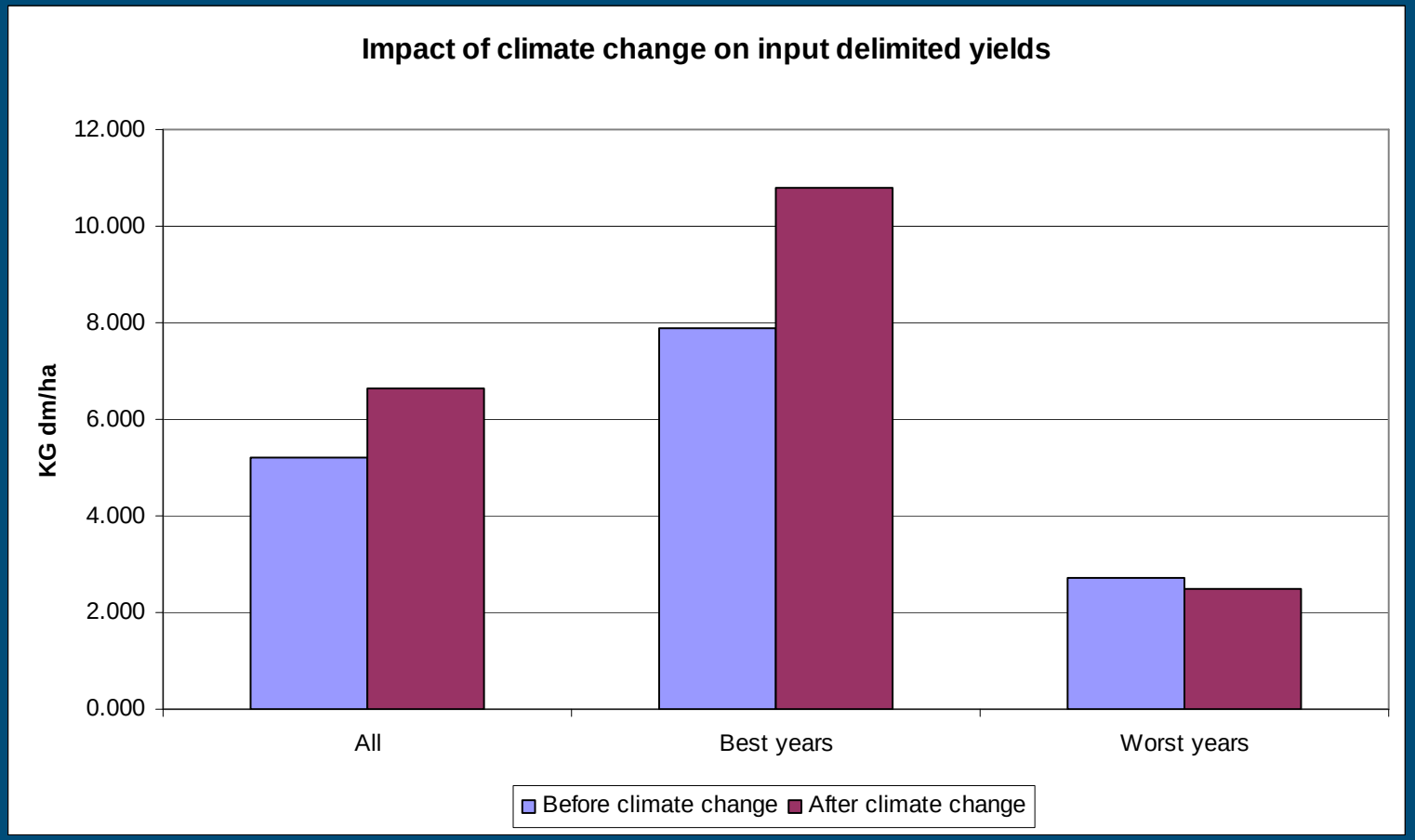

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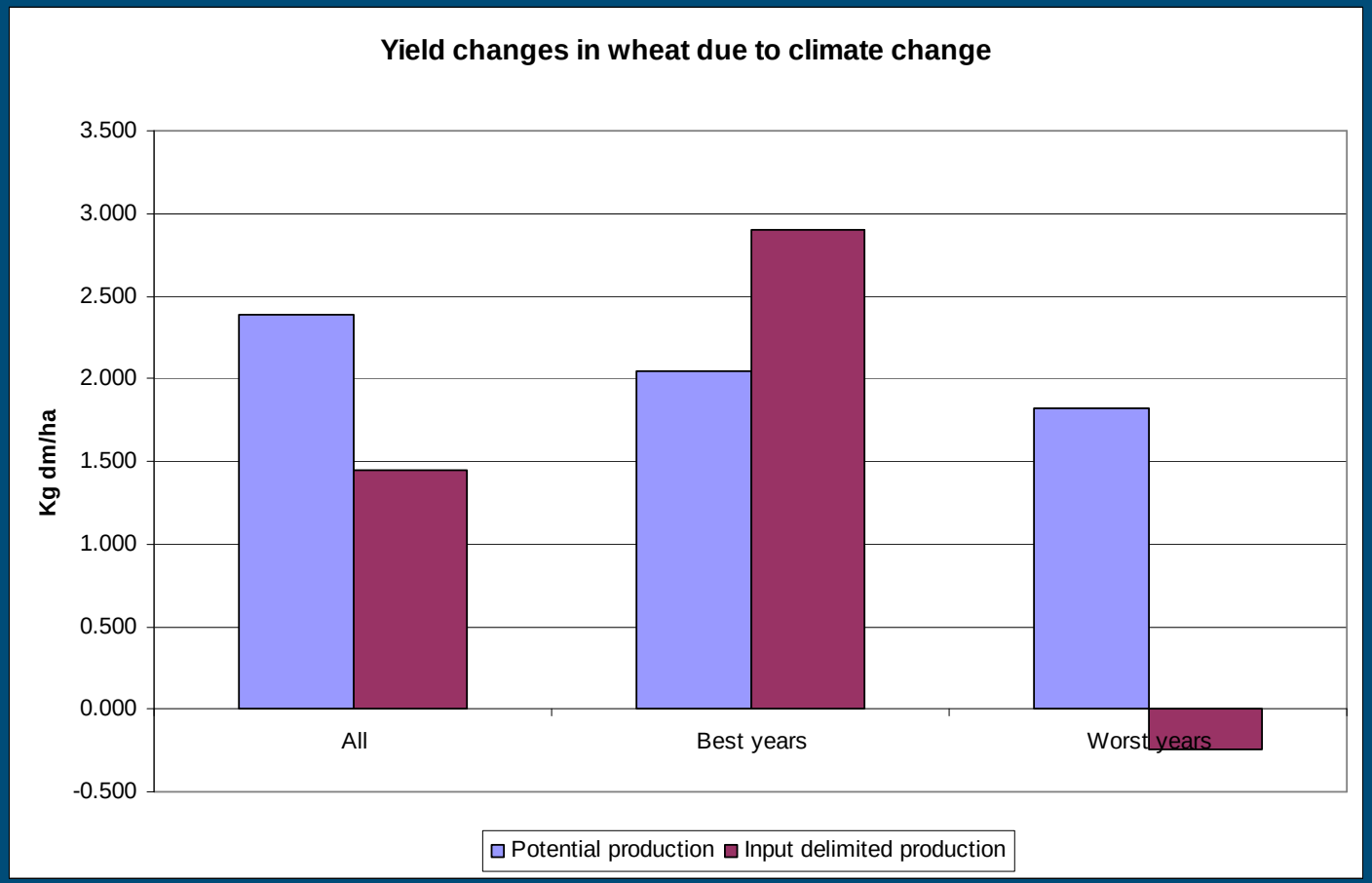

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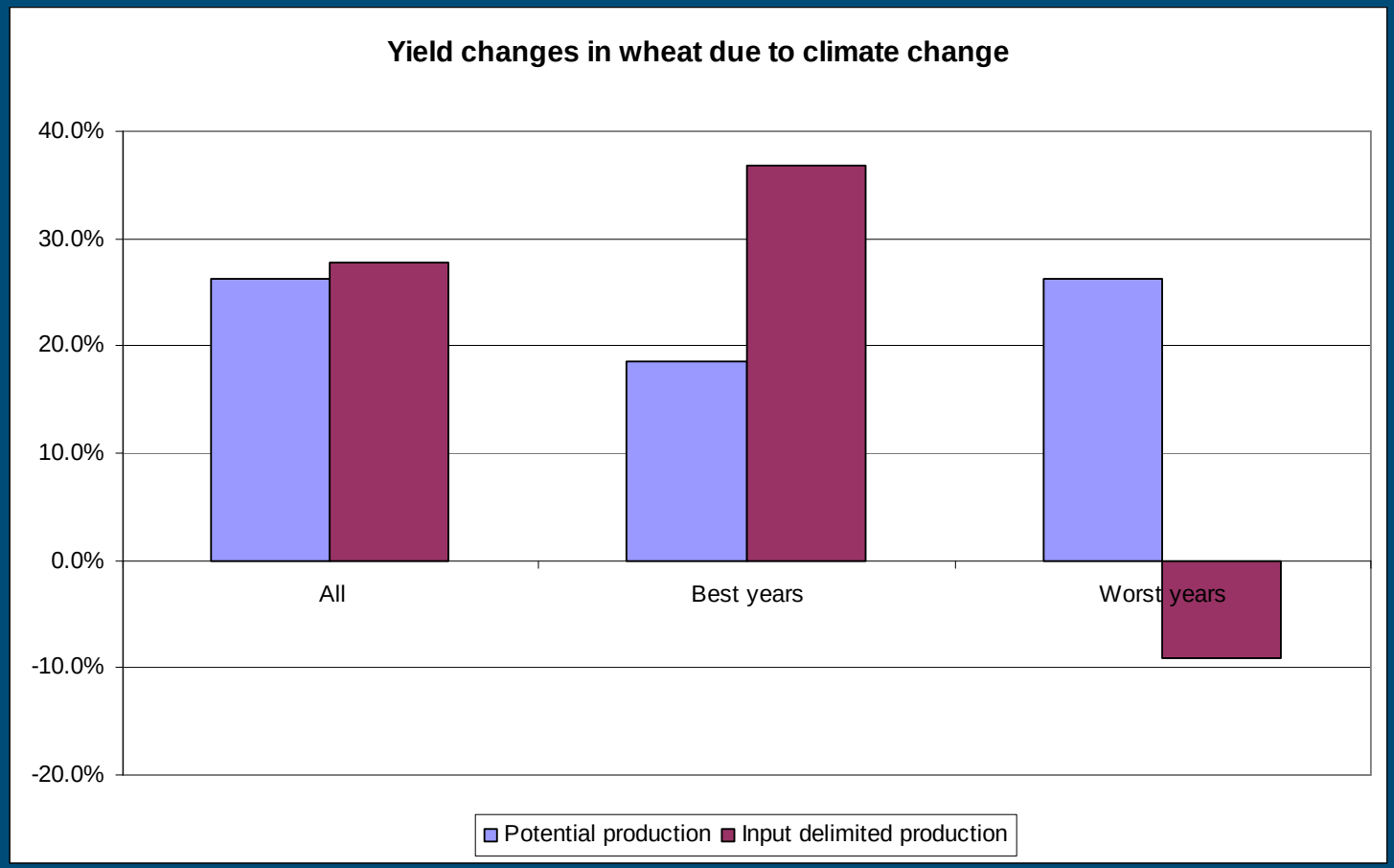

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Discussion

- Average yield increase in wheat 25%
- Good / bad years diverge
- Potential / input delimited yield levels
- Input availability more important
- Impact on availability / prices

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Conclusion

- Climate change will affect biomass availability
- Increased impact:
  - Sensitive crops / soils
  - Less inputs applied

Interesting times are ahead of us..

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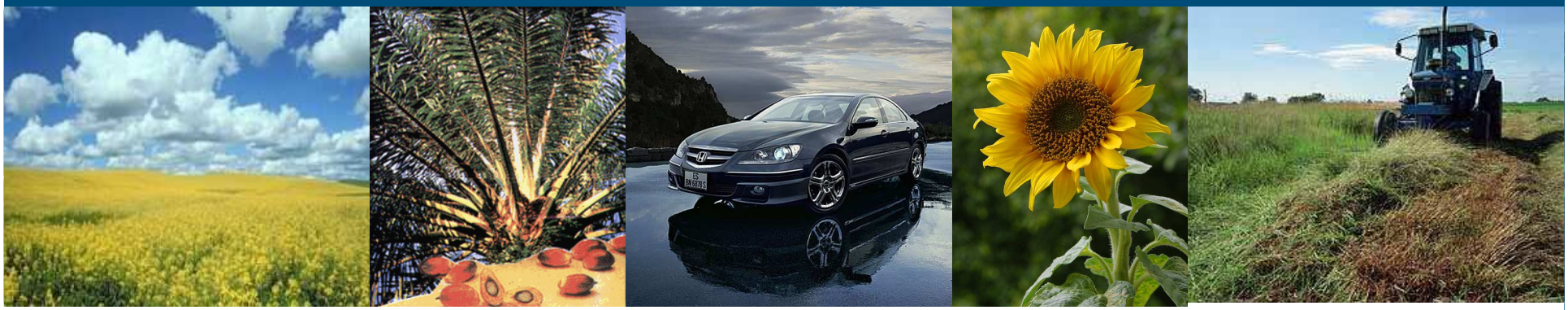

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