

Regional Crop Modeling: How Future Climate May Impact Crop Yields in Switzerland

Niklaus Lehmann, Robert Finger

Background

- Agricultural yields and income are highly dependent on weather and climate conditions.
- Within the last years, climatic extreme events have led to agricultural yield losses throughout Switzerland [1].
- Climate change will influence potential and realized yields in Swiss crop production [2].

Q1 - Influence of Weather, Soil and Management

Method:

- Multiple regression model: $\text{Yield} = f(\text{Weather, Soil, Management})$
- Data: Farm Accountancy Data Network (FADN) - Bookkeeping data from more than 3000 Swiss farms, daily MeteoSwiss data, soil aptitude map of Switzerland
- Calculation of average values of yield-, weather- and management-values for 12 study regions (Fig 1) for the period 1990-2008.
- Weather variables, e.g.: growing degree days, moisture indexes, precipitation sums
- Management variables, e.g.: direct payments, fertilizer costs

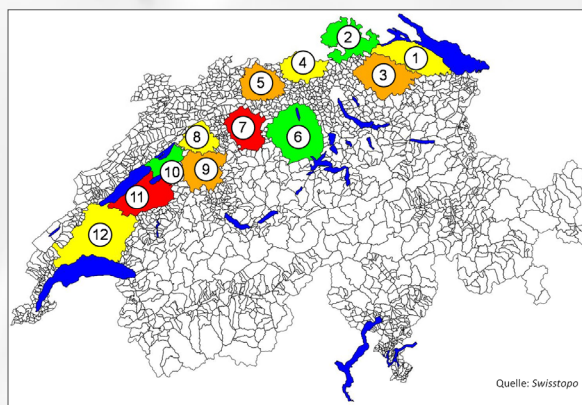


Figure 1:
12 Study Regions

Quelle: Swisstopo

Results:

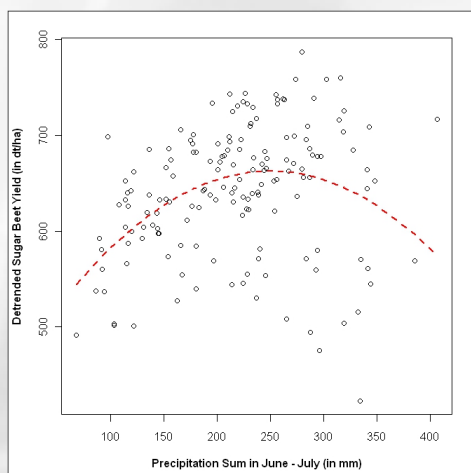


Figure 2:
Relationship between regional potato yields and the precipitation sum for the period April - August

- Weather, soil and management explain between 65% and 85% of the observed variability in regional crop yields
- Management has a rather small influence, while climate and soil are most important determinants influencing regional crop yields
- Climate often has an U-shaped influence (e.g. Fig. 2) on crop yields

References:

- [1] Fuhrer, J.; Beniston, M.; Fischlin, A.; Frei, C.; Goyette, S.; Jasper, K. & Pfister, C.: *Climate Risks and Their Impact on Agriculture and Forests in Switzerland*; Climatic Change, November 2006, 79, 79-102[24]
- [2] Calanca, P.; Fuhrer, J.; Jasper, K.; Torriani, D. & Keller, F.: *Klimawandel und landwirtschaftliche Produktion*, Agrarforschung, 2005, 12(09), 392-397

Research Questions

- Q1) Which influence have weather- and soil-conditions as well as crop management on cereal, potato and sugar-beet yields in Switzerland?
- Q2) How will climate change affect the yield levels and yield variability of these crops?

Q2 - Impact of climate change on crop yields

Method:

- Generation of daily weather for current and future (A1B) climate data using the LARS weather generator for the 12 regions
- Regional estimation of future cereal, potato and sugar beet yields using the estimated regression models (Q1) and simulated weather data

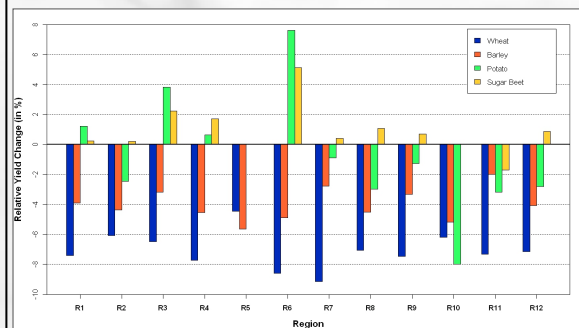


Figure 3:
Relative changes in crop yields for the 12 regions (Fig. 1) evaluated for the time horizon 2046-2065, compared with current yields.

Results:

- Negative impacts of climate change on wheat and barley, ambiguous but rather positive impacts on potato and sugar beet yields
- Impacts differ between regions and crops

Region	Wheat	Barley	Potato	Sugar Beet
1	+11%	+5%	-16%	+3%
2	+19%	+2%	-4%	+7%
3	+0%	+3%	-37%	-32%
4	+22%	+5%	-21%	-7%
5	+34%	+7%	NA	NA
6	+0%	+4%	-56%	-54%
7	-5%	+1%	-17%	-8%
8	+26%	+6%	-18%	-5%
9	+13%	+4%	-22%	-4%
10	+28%	+7%	-3%	+10%
11	+5%	+2%	+1%	+14%
12	+21%	+2%	-28%	-13%

Table 1:
Relative changes in yield variability evaluated for the time horizon 2046-2065, compared with current yield variability.

- Impacts on yield variability is ambiguous, however, climate change tends to increase variability of wheat and barley, but decreases potato and sugar beet yield variability

Conclusions

- Impacts of climate change on crop yields in Switzerland differ between regions — impacts are site- and crop specific
- In general, the here estimated impacts of climate change on Swiss crop production are of small magnitude, in line with the results of other studies
- The here applied regression approach over-estimates negative impacts of climate change because CO₂ fertilization and adaptation are not considered
- The results indicate that shifts of sowing and harvest dates as well as regional re-allocation of crop production might avoid negative impacts