Shifts in N-efficiency of different farm types in response to climate change

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Introduction Climate change may affect European farms, but – in contrast to individual crops - the sensitivity of whole farming systems has not been the subject of much research. At the farm level, where different farm units are linked through the availability and flow of nitrogen (N), effects on individual crops are interlinked, and through shifts in grasslands and related animal production with altered nutrient flows. Ideally, N flows into the system and N-export with products should be equal, and thus N-use-efficiency (NUE), expressed as the ratio of N export to N loss, would be maximal. The objective of this study was to test the effect of gradually changing temperature (T) and precipitation (P) on NUE of two farm types under Swiss conditions.

Model description A Stella© model (CH-Farm) with a monthly time step was developed for a mixed dairy/arable farm. CH-Farm is a statistical model, which uses relations inferred from functional models to represent the effect of climate change on arable crops (CropSyst) and grasslands (Pasture Simulation Model, PaSim). CH-Farm is implemented with a limited number of input variables and relations describing the effect of T and P on N fluxes between 5 subsystems: soil, grass, crops, animals (milking cows) and manure (Figure 1). The model was applied to 2 farm types and driven by a set of climate scenarios with 20 years of historical data (1980-2000), followed by a progressive shift in T and P until 2100 (Table 1), with (+) or without (-) consideration of CO_2 fertilization effects.

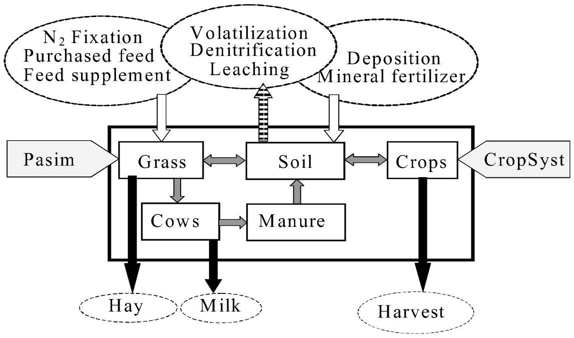

Figure 1 Structure of farm model CH-Farm

Table 1 Climate scenarios and farm types

Scenario	ΔT (2100)	ΔP (2100)
'Warm-wet' (WW)	+2 °C	+5%
'Hot-dry' (HD)	+5 °C	-20%

Farm types:
Farm D : 30 cows, 8 ha cropland (mainly dairy)
Farm C : 15 cows, 15 ha cropland (mainly arable)

Results NUE of the farm with mainly dairy production increased or remained steady over time (Figure 2); this was due to an extension of the period of grass growth and accelerated plant development leading to higher grassland and pasture production. Conversely, the farm with more arable land showed decreasing NUE, which was related a loss of crop productivity. For each farm type, NUE was generally higher with the WW scenario compared to the corresponding HD scenario because of stronger limitations of productivity by T and water of the latter. Scenarios considering effects of elevated CO_2 (+) increased NUE due increased plant N uptake from the soil, and correspondingly less N loss.

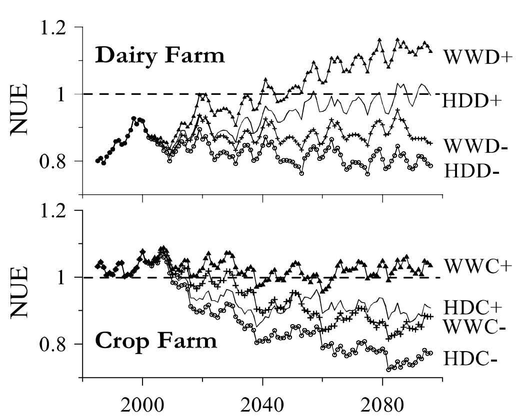

Figure 2 Trend in NUE for different farming systems and climate scenarios

Conclusions
1. Grassland and pasture productivity benefit from the longer growing season, while crop production decreases due to acceleration plant growth.
2. NUE of arable farms is more likely to decline with climate change, i.e. more N is lost per unit of production, while NUE of dairy farms remains steady or increases.
3. Consequently, the distribution of land between different production units has an important effect on the trend of NUE.
4. Drier (HD) scenarios cause lower NUE compared to wetter (WW) scenarios. With HD scenarios, limitation of production by T is more important than effects of changed precipitation.