Modelling effects of agricultural policies on regional greenhouse gas emissions from cattle raising production systems in Baden-Württemberg (southwest Germany)

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Introduction In the light of the anthropogenic climate change and the resulting need to mitigate greenhouse gas (GHG) emissions, policies are needed which efficiently abate GHG emissions in the agricultural sector. However, reliable estimates of regional GHG abatement potentials in the agricultural sector are rare because the models do not integrate the economic and environmental effects of different agricultural policies and are generally restricted to a single-gas approach. Coupling an economic sector model with a process-oriented ecosystem model can overcome this gap and thus provide realistic *exante* information of socioeconomically and environmentally sustainable agricultural policies.

Materials and methods The process-oriented ecosystem model DNDC (Li, 2000) was coupled with the economic farm model EFEM (Angenendt *et al*., 2002) via a database interface, and georeferenced soil, land use, management, and climatic data were used to simulate regionally disaggregated GHG emissions of grassland soils and cattle raising (dairy and meat) production systems in the state of Baden-Württemberg (southwest Germany). EFEM simulates production systems on farm level using Linear Programming to maximise return rates. EFEM was run for a series of realistic and feasible policy measures, including a 30€ tax per ton CO_2 on all emitted GHG, and a tripling of N fertilizer costs. Simulated environmental and economic effects of reduced livestock densities are being prepared.

Results Table 1 shows that both the 30€ tax on GHG and the 3-fold N fertilizer price reduced gross margin by about 10% and abated GHG by around 8% when compared to the reference scenario. Raising the fertilizer price was slightly more efficient with respect to reducing soil borne emissions whereas the tax on GHG led to a stronger reduction of ruminant CH_4 emissions due to a slightly altered feeding scheme. The soil emissions of the simulated policy measures were lower than the reference because less mineral fertilizer-N was applied whereas the application of organic N as slurry or farmyard manure remained nearly the same. Organic fertilizer application rates were only slightly reduced because livestock density was unaffected from management responses to the policy measures. Regional livestock density, however, explains nearly 90% of GHG emission variation in cattle raising production systems (Figure 1).

Table 1 Economic and environmental effects of mitigation strategies on dairy production systems

	Reference	GHG tax	N price
Gross margin (€ ha^{-1})	1260	1120	1140
GHG_{total} (kg CO_2-eq ha^{-1})	5110	4690	4710
GHG_{soil} (kg CO_2-eq ha^{-1})	1120	980	940
N_2O_{soil} (kg N ha^{-1})	3.71	3.28	3.15
Fertilizer N_{min} (kg ha^{-1})	108	75	60
Fertilizer N_{org} (kg ha^{-1})	50	43	45
Livestock density (LS ha^{-1})	1.03	1.03	1.03

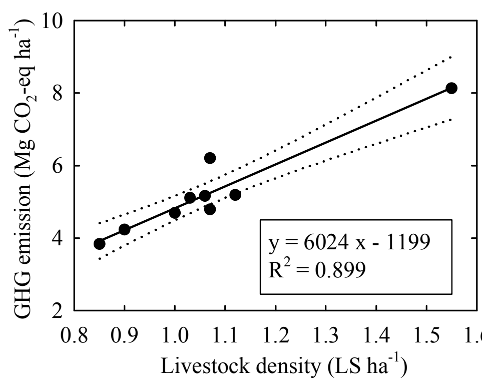

Figure 1 GHG emission vs. livestock density

Conclusions The results of the study suggest that taxes on either GHG or N fertilizers are efficient measures to reduce GHG emissions in cattle raising production systems. Since livestock density is so closely correlated to the overall GHG emissions, extensification is probably the most effective mitigation measure. Further simulations will show how a reduction of livestock density will affect environmental and economic parameters.

References

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