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Greenhouse gas emissions from Swiss agriculture since 1990: implications for environmental policies to mitigate global warming

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Abstract

Agricultural greenhouse gas (GHG) emissions contribute significantly to global warming, and environmental protection strategies have thus to integrate emission reduction measures from this source. In Switzerland, legislation together with monetary incentives has forced primarily integrated, and to a lesser extend organic farming, both covering nowadays more than 95% of the agriculturally useful area. Though reducing greenhouse gas emissions was not a primary intention of this reorganisation, the measures were successful in reducing the overall emissions of nitrous oxide and methane by 10% relative to 1990. A reduction of the animal herd, namely of dairy cattle, non-dairy cattle and swine, and decreasing inputs of mineral N are the main contributors to the achieved emission reduction. Crop productivity was not negatively affected and milk productivity even increased, referring to the ecological potential of agricultural reorganisation that has been tapped. Total meat production declined proportional to the animal herd. Stabilised animal numbers and fertiliser use during the last 4 years refer to an exhaustion of future reduction potentials without further legislative action because this stabilisation is most likely due to the adaptation to the production guidelines. A comparison of emission trends and carbon sequestration potentials in the broader context of the EU15 reveals that nitrous oxide (N_2O) and methane (CH_4) have been reduced more efficiently most probably due to the measures taken, but that sequestration potentials are smaller than in the EU15 mainly because of differences in the agricultural structure. The change from an intensified towards a more environmental sound integrated production has a significant reduction potential, but in any case, agriculture will remain a net GHG source in spite of emission mitigation and carbon sequestration.

Keywords: Greenhouse gas; Integrated production; Organic farming; Cattle; Legislation; Carbon sequestration; Uncertainty

1. Introduction

Agricultural extensification measures aimed at reducing the overall environmental impact of intensive agricultural production have the potential also to reduce greenhouse gas (GHG) emissions. Evaluating such measures from an environmental viewpoint needs to consider potential losses of productivity as well as long-term potentials and their sustainability. Though the overall contribution of Swiss agriculture to the global GHG budget is small, its progress in developing a more environmentally sound production by maintaining productivity at a high level may help to elucidate possible impacts of agricultural environmental policies also at a broader scale.

Since 1993, the Swiss federal government has given financial support to national programmes applied to the agricultural sector and affecting all sectors of agricultural production, including plant production, soil and groundwater protection, and animal welfare. In 1998, a new agricultural law linked all direct payments to the provision of the required standard of ecological performance (REP). This programme aims at comprising an overall scheme of measures particularly respectful to the reduction of environmental risks. Integrated production (IP) and organic farming are favoured as special voluntary efforts with direct payments, and monetary incentives are not longer coupled to production. This policy contains key elements of the so called ‘‘cross compliance’’ mechanism of the EU, which is a major element of the fundamental reform of the European Agricultural Policy (CAP).

The goal of reducing GHG emissions was not causative for the implementation of the new legislation, but a

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concomitant decrease in the emissions of nitrous oxide (N_2O) and methane (CH_4) in Swiss agriculture is well documented and can be ascribed to the above mentioned measures. Agriculture contribute by around 71 and 62% of the total national emissions of N_2O and CH_4, respectively, and is thus a key source. The corresponding values for EU15 are 70% (N_2O) and 42–47% (CH_4; Freibauer, 2003). Together, the contribution of these two gases is at around 15% of the total GHG emissions (CO_2-equivalents) of Switzerland (EU15: 10%, UNFCCC).

Key points of IP in Switzerland are a balanced use of nutrients, a diversified crop protection, a share of 7% of ecological compensation areas (permanently extensified grasslands and extensified temporary grasslands in arable rotations converted for 2–6 years with no or little fertilisation), and a soil protection scheme, encouraging soil covering to prevent erosion. A balanced use of nitrogen (N) is chargeable when nitrogen inputs [mineral N + (manure N − NH_3 loss) × 0.6%] equal nitrogen outputs ±10% on the farm level. Regarding animal husbandry, direct payments are coupled to maximum stocking densities, which in turn depend on the climatic region. Directives of REP apply similarly to organic farming, where additional constraints, in particular, a more restrictive use of mineral fertiliser input, are to be considered. Implementation of the national programmes in 1993 and the REP in 1998 was followed by a continuous increase in the share of both, IP and organic farming, to the total (Fig. 1). In 2001, both agricultural systems together covered more than 95% of the agriculturally useful area (which includes mountain farming areas converted to areas of standard yield).

General indexes of Swiss agriculture (2003) are a 26% share of arable rotations, of which 30% are leys (intensively managed temporary grasslands), and a 73% share of permanent grasslands, about half of it alpine meadows and pastures with comparable low productivity. Altogether, about 37% of the country's area is covered by agriculture. This key figures stress the importance of animal production in Switzerland, in consequence of natural conditions which favour grasslands as the major fodder source for the animal herd.

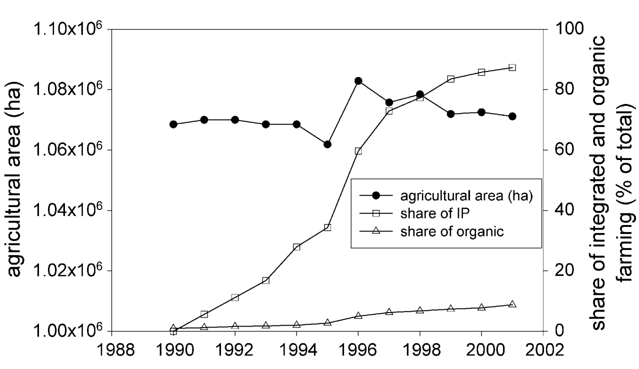

Fig. 1. Increase in the area of integrated (IP) and organic farming in Switzerland since 1990.

This paper aims to elucidate achievements and future potentials in agricultural GHG emission reduction on a sectoral basis, to evaluate the major reasons for this development, to illuminate environmental protection strategies against the background of the Swiss agricultural structure, and to discuss the potentials at an European-wide context.

2. Greenhouse gas inventory: methodology and critical evaluation

Emission data from the Swiss agricultural sector were calculated according to IPCC (2000a) with slight modifications for CH_4, and a modified method for N_2O emissions according to Schmid et al. (2000). Emission data for the main agricultural sectors are in accordance to the data provided by the Swiss authorities to the UNFCCC, but are presented here detailed, supplemented by additional information on management practices (IP, organic), yield, productivity, and underlying uncertainties.

Methane emissions distinguish between enteric fermentation and manure management. The Swiss approach for enteric fermentation in general follows the Tier 2 method (IPCC, 2000a), which is based on emission factors (kg CH_4 head^{-1} a^{-1}), calculated by means of gross energy intake, and methane conversion factors. However, a more disaggregated livestock characteristic according to Swiss official statistics is used. Ammonia (NH_3) volatilisation was calculated for individual livestock species according to Menzi et al. (1997). Calculation of CH_4 from manure management again follows Tier 2, where defaults were adopted for Bo (maximum CH_4 producing capacity) and MCF (CH_4 conversion factors), while volatile solid (VS) excretion was calculated by means of published feed intake and VS excretion of livestock categories (Minonzio et al., 1998). Methane emissions were calculated separately for sub categories of cattle (7), swine (2), horses (3), poultry (4), and for sheep and goats (1).

Nitrous oxide emissions after IPCC (2000a) distinguish between manure management and emissions from agricultural soils. Emissions from manure management are a function of the number of animals, N excretion per species or animal category, fraction of N excreted per manure management system, and the N_2O emission factors, which are linked to the manure management system. Direct soil emissions are based on the application of mineral and manure N (minus fraction of NH_3 volatilised), amount of N fixed by legumes, amount of N mineralised by crop residue decomposition, area of organic soils, and the corresponding N_2O emission factors. Indirect soil emissions include N_2O from atmospheric deposition and from run-off and leaching.

In the Swiss inventories, basically the same emissions factors are used as by IPCC, 2000a (Tier 1b method),