Greenhouse gas inventory of agriculture in the Czech Republic

Z. Exnerová, E. Cienciala

Institute of Forest Ecosystem Research, Jílové u Prahy, Czech Republic

ABSTRACT

As a part of its obligations under the Climate Convention, the Czech Republic must annually estimate and report its anthropogenic emissions of greenhouse gases. This also applies for the sector of agriculture, which is one of the greatest producers of methane and nitrous oxide emissions. This paper presents the approaches applied to estimate emissions in agricultural sector during the period 1990–2006. It describes the origin and sources of emissions, applied methodology, parameters and emission estimates for the sector of agriculture in the country. The total greenhouse gas emissions reached 7644 Gg CO_2 eq. in 2006. About 59% (4479 Gg CO_2 eq.) of these emissions has originated from agricultural soils. This quantity ranks agriculture as the third largest sector in the Czech Republic representing 5.3% of the total greenhouse gas emissions (GHG). The emissions under the Czech conditions consist mainly of emissions from enteric fermentation, manure management and agricultural soils. During the period 1990–2006, GHG emissions from agriculture decreased by 50%, which was linked to reduced cattle population and amount of applied fertilizers. The study concludes that the GHG emissions in the sector of agriculture remain significant and their proper assessment is required for sound climate change adaptation and mitigation policies.

Keywords: greenhouse gas inventory; agriculture; enteric fermentation; manure management; agricultural soils; methane emissions; nitrous oxide emissions

Under the United Nations' Framework Convention on Climate Change (UNFCCC), each country listed in Annex I of the Convention must annually conduct a national greenhouse gas (GHG) inventory of its anthropogenic emissions by sources and sinks. According to the Kyoto Protocol agreements, the Czech national GHG emissions during the five-year commitment period from 2008 to 2012 have to decrease by 8% below the emissions in the base year (1990). The annually submitted National Inventory Report (NIR) contains detailed and complete information on emission inventory and the activity data. To ensure transparency and comparability, the information on estimated emission values are reported in a Common Reporting Format (CRF) tables, which are prepared by the UNFCCC secretariat. The emission reports are periodically reviewed by independent expert teams appointed by UNFCCC.

In order to ensure consistency, transparency and comparability of estimates among countries, the estimation and reporting must follow methodological guidance developed by the Intergovernmental Panel on Climate Change (IPCC 1997–2000, 2006). While the Revised 1996 IPCC Guidelines presents the basic methods based on default parameters, Good Practice Guidance (IPCC 2000) contains more complex approaches that require detailed country-specific data on different variables. For example, an assessment of gross energy for cattle sub-category was earlier possible only using the default factors (so called Tier 1 method, see below), while after the adoption of IPCC 2000, a more specific calculation was possible. The GHG emission inventory utilizes different approaches, the selection of which depends on importance/significance of the source emission categories. This forms the concept of key categories. The key categories are those, which jointly constitute 95% of the aggregated emissions of the total GHG inventory. Hence, key categories may belong to different sectors and may be qualified by individual greenhouse gases.

The applicable methodologies for emission estimates follow hierarchy of tiers, from most simple to most complex. The basic, Tier 1 methods are typically characterized by simple calculations based on the aggregated statistical data and on use of generally recommended (default) emission factors of continental or global applicability. These are tabulated directly in the methodical manuals (Revised 1996 IPCC Guidelines, IPCC 1997; Good Practice Guidance IPCC 2000). The Tier 2 methods are based on more sophisticated calculation and usually require more detailed statistical data. The emission factors (country-specific or technology-specific) are usually derived from calculations based on regional and specific studies and better information about the source category. Even in these cases, it is sometimes possible to find the necessary parameters for the calculation in the IPCC manuals. Finally, the Tier 3 methods usually require data from direct measurements carried out under the local conditions. The individual countries – parties to the Kyoto protocol is encouraged to develop its country-specific methods with available data and adopt the higher Tier level (2 or 3) of emission estimation.

Agriculture is one of six sectors in the national emission inventory. Agricultural greenhouse gas emissions under the Czech conditions consist mainly of emissions from enteric fermentation (CH_4 emissions only), manure management (CH_4 and N_2O emissions) and agricultural soils (N_2O emissions only). The other IPCC subcategories such as rice cultivation, prescribed burning of savannas, field burning of agricultural residues do not occur in the Czech Republic.

As for enteric fermentation, methane emissions originate from animal breeding (digestive processes), which is manifested most for ungulate animals (mostly cattle). As for manure management, this category includes emissions from manure management of livestock, or from animal waste management systems. The emissions from agricultural soils are derived from inorganic nitrogen-containing fertilizers, manure from animal breeding and nitrogen contained in parts of agricultural crops that are returned to the soil. In addition, the indirect emissions are derived from atmospheric deposition and from nitrogenous substances flushed into water courses and reservoirs.

The aim of this study is to describe the currently adopted inventory methods to estimate greenhouse gas emissions in the sector of agriculture in the Czech Republic and to quantify these emissions and discuss their trends.

MATERIAL AND METHODS

The Czech national emission inventory for the sector of agriculture follows the IPCC methodology, specifically Revised 1996 IPCC Guidelines (IPCC 1997) and Good Practice Guidance (IPCC 2000).

The Czech national emission inventory of agriculture is based on Tier 1 and Tier 2 methods. The more advanced methods utilizing country-specific information (Tier 2) were applied in the calculation of emissions from enteric fermentation related to cattle populations. Tier 3 methodologies are not used, because the required country-specific data and local procedures are not available yet.

All GHG emissions are reported in aggregated units, in Gg CO_2 eq. The methane and nitrous oxide emissions have to be converted multiplied by appropriate conversion factors GWP (Global Warming Potential). GWP corresponds to the factor by which the given gas is more effective in absorption of terrestrial radiation than CO_2 (1 for CO_2, 21 for CH_4 and 310 for N_2O).

Activity data. The activity data were mostly obtained from the official statistics prepared by the Czech Statistical Office (CSO), which are published annually, especially in the Czech Statistical Yearbooks. Some country-specific technical data (feeding situation, weight of cattle, weight gain, etc.) were also provided by experts from agricultural research institutions. Data were processed in Excel spreadsheets. After calculations, the relevant data were put into the Common Reporting Format (CRF) tables of the UNFCCC for reporting.

Enteric fermentation. This category includes emissions from cattle (dairy and non-dairy cattle), swine, sheep, horses and goats. The enteric fermentation emissions from poultry category were not estimated, because the IPCC Guidelines do not provide suitable emission factor for this animal category.

Emissions from enteric fermentation of domestic livestock are calculated by using IPCC Tier 1 and Tier 2 methodologies according to the Revised IPCC Guidelines (IPCC 1997) and IPCC Good Practice Guidance (IPCC 2000) methodologies. Methane emission for cattle, which is a dominant source in this category, are calculated using the Tier 2 method, while for other livestock the Tier 1 method was used.

Cattle category. The emission factor for methane from fermentation (EF) in kg/head p.a. according to the Revised 1996 IPCC Guidelines (IPCC 1997), Good Practice Guidance (IPCC 2000) is proportional to the daily food intake and the conversion factor. It thus holds that:

$$EF_i = 365/55.65 \times DFI_i \times Y \quad (1)$$

where: *DFI* (daily food intake, in MJ/day) is taken as the mean feed ration for the given type of cattle (there are several subcategories of cattle) and Y is the conversion factor for cattle (Y = 0.06). Coefficient 55.65 has dimensions of MJ/kg CH_4 (IPCC 2000). In principle, this equation should be solved for each cattle subcategory, denoted by index i. The Czech Statistical Office provides cattle categories: calves younger than 6 months of age, young cattle 6–12 months of age (young bulls, young heifers), bulls over 1 year of age, including bullocks (1–2 years, over 2 years), heifers 1–2 years of age, heifers over 2 years of age and cows.

In the calculation, it is also very important to distinguish between dairy and sucker cows (nursing cows), where the fraction of sucker cows (sucker cows/all cows) gradually increased in the 1990–2006 time period from 2.4% assessed for 1990 to 24.5% for 2006.

According to the IPCC methodology, Tier 2 (IPCC 1997, 2000, Kolář et.al. 2004), the 'daily food intake' for each subcategory of cattle is not measured directly, but is calculated from national zoo-technical inputs, mainly weight (including the final weight of mature animals), weight gain (for growing animals), daily milk production including the percentage of fat (for cows) and the feeding situation (stall, pasture). The national zoo-technical inputs (noted above) were updated by expert from the Czech University of Life Sciences in Prague (Hons and Mudřík 2003, Mudřík and Havránek 2006). Percentages of pasture are related only to the summer part of the year (180 days), while only the stall type is used in the rest of year. Milk production statistics come from CSO, in which only milk from dairy cows is considered. The daily production of milk rapidly increased from 14.80 l/day/head in 2004 to 17.13 l/day/head in 2005 and 17.45 l/day/head in 2006, on the other hand the fat content decreased slowly. The relevant daily milk production of sucker cows (3.5 l/day/head) was used for the calculation.

The emissions from enteric fermentation of cattle are calculated after Eq. 2 (IPCC 1997):

$$CH_4 \text{ emissions} = EF_i \times \text{population}_i \quad (2)$$

where: EF is country-specific emission factor for the defined livestock population (kg/head/year) and population is number of head in the defined livestock population.

Other livestock category. Compared to cattle, the contribution of other farm animals to the whole CH_4 emissions from enteric fermentation is much smaller, only about 5%. Therefore, CH_4 emissions from enteric fermentation of other farm animals (other than cattle) are estimated by the Tier 1 approach. Because some features of livestock kept in the Czech Republic are similar to those of the West-European neighbouring countries, the default EFs for Tier 1 approaches recommended for Western Europe were employed. The values of these emission factors (IPCC 1997) applicable for developed countries are shown in Table 1.

Manure management. This emission source covers manure management of domestic livestock. Both nitrous oxide (N_2O) and methane (CH_4) emissions from manure management of livestock (cattle, swine, sheep, horses, goats and poultry) are reported. Three animal waste management systems (AWMS) are distinguished for emission estimations: liquid[1], solid[2] and other manure management systems.

Nitrous oxide is produced by the combined nitrification-denitrification processes occurring in the manure nitrogen. Methane is produced in manure during decomposition of organic material by anaerobic and facultative bacteria under anaerobic conditions. The amount of emissions is dependent e.g. on the amount of organic material in the manure and climatic conditions after equations (IPCC 1997):

$$Nex_{(AWMS)} = \sum_T [N_{(T)} \times Nex_{(T)} \times AWMS_{(AWMS)}] \quad (3)$$

where: $Nex_{(AWMS)}$ is N excretion per $AWMS$ (kg/yr), $N_{(T)}$ is number of animals of type T in the country, $Nex_{(T)}$ is N excretion of animals of type in the country (kg/N/animal/year),

Table 1. Enteric fermentation methane emission factors applicable for individual livestock categories in developed countries (IPCC 1996, Table 4)

Livestock type	Enteric fermentation methane emission factor (kg CH_4/head/year)
Buffalo	55
Sheep	8
Goats	5
Horses	18
Swine	1.5
Poultry	not estimated

[1]Dung and urine are collected and transported in liquid state to tanks for storage. Liquid may be stored for a long time. To facilitate handling water may be added.

[2]Dung and urine are excreted in a stall. The solids are collected and stored in bulk for a long time before disposal, with or without liquid runoff into a pit system.

$AWMS_{(T)}$ is fraction of $Nex_{(T)}$ that is managed in one of AWMS for animals of type in the country, T is type of animal category.

The N_2O emissions from all animal waste management systems in the country are calculated by form (IPCC 1997):

$$N_2O_{(AWMS)} = \Sigma[Nex_{(AWMS)} \times EF_{3(AWMS)}] \quad (4)$$

where: $Nex_{(AWMS)}$ see Eq. 3 and $EF_{3(AWMS)}$ is N_2O emission factor for an AWMS (IPCC 1997, Table 4).

Conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by using the following equation (IPCC 2000):

$$N_2O = N_2O - N \times 44/28 \quad (5)$$

In respect to Table 3 where methane emissions from the decomposition of animal excrements (manure) were classified as a non-key source, preference was given to determination in Tier 1. Eq. 6 (IPCC 2000) shows how to calculate emissions from manure management for a defined population:

$$CH_4 \text{ emissions} = EF_i \times \text{population}_i \quad (6)$$

where: EF is emission default factor for the defined livestock population (Revised 1996 IPCC Guidelines 1997, Table 4, factors for Western Europe and cool climate region, in kg/head/year) and population is number of head in the defined livestock population.

Agricultural soils. This source category includes direct and indirect nitrous oxide emissions from agricultural soils. Nitrous oxide is produced in agricultural soil as a result of microbial nitrification-denitrification processes. The processes are influenced by chemical and physical characteristics (availability of mineral N substrates and carbon, soil moisture, temperature, and pH). Thus, addition of mineral nitrogen in the form of mineral fertilizers, manure, crop residues, N-fixing crops enhance the formation of nitrous oxide emissions.

Nitrous oxide emissions from agriculture include these subcategories: (i) direct emissions from agricultural soils (emissions from mineral fertilizers, animal manure management, crop residue, and N-fixing crops), (ii) emissions from pasture manure (pasture range and paddock)[3], (iii) indirect emissions coming from atmospheric deposition and (iv) indirect emissions from nitrogenous substances flushed into water courses and reservoirs.

Nitrous oxide emissions from agriculture are calculated and analyzed by the Tier 1 approach of the IPCC methodology (IPCC 1997). The standard calculation of Tier 1 required the following input data: number of head of farm animals (dairy cows, other cattle, pigs, sheep, poultry, horses and goats), annual amount of nitrogen applied in the form of industrial fertilizers and annual harvest of cereals and legumes.

The direct N_2O emissions from agricultural soils are estimated as follows (IPCC 2000):

$$N_2O_{direct} - N = [(F_{SN} + F_{AM} + F_{EN} + F_{CR}) \times EF_1] \quad (7)$$

where: F_{SN} is annual amount of nitrogen applied in the form of industrial fertilizers, F_{AM} is annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilizes as NH_3 and NO_x, F_{BN} is amount of nitrogen fixed by N-fixing crops cultivated annually, F_{CR} is amount of nitrogen in crop residue returned to soils annually and EF_1 is emission factor for emission from N inputs (kg N_2O-N/kg N input).

The indirect N_2O emissions coming from atmospheric deposition are estimated as follows (IPCC 2000):

Table 2. The emission factors (EFs) for the calculation of N_2O emissions from agriculture (IPCC 1996)

	Emissions (sources)	Values
EF_1	direct emissions – cultivated soils	0.0125 kg N_2O-N/kg N
EF_3	AWMS – liquid storage	0.001 kg N_2O-N/kg N
	AWMS – solid storage	0.02 kg N_2O-N/kg N
	AWMS – other	0.005 kg N_2O-N/kg N
	AWMS – grazing animals	0.02 kg N_2O-N/kg N
EF_4	indirect emissions – atmospheric deposition	0.01 kg N_2O per kg emitted NH_3 and NO_x
EF_5	indirect emissions – leaching	0.025 kg N_2O per kg of leaching N

[3]The manure from pasture and range grazing animals is allowed to lie as is, and is not managed

$$N_2O_{(G)} - N = [(N_{FERT} \times Frac_{GASM}) + (\sum_T(N_{(T)} \times Nex_{(T)}) \times Frac_{GASM})] \times EF_4 \quad (8)$$

where: N_{FERT} is total amount of nitrogen fertilizers applied to soils (kg N/year), $\Sigma(N_{(T)} \times Nex_{(T)})$ is total amount of animal manure nitrogen excreted in a country (kg N/year), $Frac_{GASF}$ is fraction of nitrogen fertilizer that volatilizes as NH_3 and NO_x, $Frac_{GASM}$ is fraction of animal manure N that volatilizes as NH_3 and NO_x and EF_4 is emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces. The values of $Frac_i$ parameters are available in Table 4 (IPCC 1997).

The emissions from grazing animals – pasture range and paddock – are estimated as in Eq. 4 with relevant emission factor EF_3 (Table 2). The indirect N_2O emissions coming from leaching/runoff are estimated as follows (IPCC 2000):

$$N_2O_{(L)} - N = [N_{FERT} + \Sigma(N_{(T)} \times Nex_{(T)}) \times Frac_{LEACH} \times EF_5 \quad (9)$$

where: N_{FERT} is total amount of nitrogen fertilizers applied to soils (kg N/year), $\Sigma(N_{(T)} \times Nex_{(T)})$ is total amount of animal manure nitrogen excreted in a country (kg N/yr), $Frac_{LEACH}$ is fraction of N that leaches and EF_5 is emission factor for leaching/runoff.

IPCC default emission factors (EF) were used for calculating N_2O emissions from agricultural soils. The emission factors for calculation of emissions of agricultural soils and AWMS were used according to Table 2. The value of $Frac_{LEACH}$ parameter is available in Table 4 (IPCC 1997).

RESULTS AND DISCUSSION

The estimated emissions for the sector of agriculture equaled 7644 Gg CO_2 Eq. in 2006. In relation to 15 473 Gg CO_2 Eq. in a base year 1990, it means 50% emission reduction. The agricultural emissions include methane and nitrous oxide emissions (37% and 63% of the agricultural emission budget). Approximately 59% (4479 Gg CO_2 Eq.) of emissions comes from agricultural soils, while 30% originated from enteric fermentation and 11% from manure management systems. The emission share of the agricultural sector remains about the same during the estimated time period 1990–2006 (Figure 1).

The estimated emissions rank agriculture as the third largest sector in the Czech Republic representing 5.3% of the national total GHG emissions (about 82% of emissions comes from the sector of energy and 10% originates from the sector of industrial processes). In the period 1990–2006, the emissions from agriculture decreased by 50%, with the largest decline observed from 1990 to 1994. At that time, the large transformation and adaptation to new economic conditions in this sector were initialized after the collapse of the socialistic regime in 1989. It becomes apparent that the conditions in agriculture were largely stabilized since 1994. The estimated emissions

Table 3. Overview of significant categories in this sector (2006)

Category	Character of category	Gas	Total GHG (%)
Agricultural soils, direct emissions	key category	N_2O	1.7
Enteric fermentation	key category	CH_4	1.5
Agricultural soils, indirect emissions	key category	N_2O	1.2
Manure management	key category	CH_4	0.3
Pasture, range and paddock manure	key category	N_2O	0.2
Manure management	non-key category	N_2O	0.2

Table 4. The emission inventory data of agricultural sector in the neighbouring countries

	Agricultural emissions in 2005 (Gg CO_2 Eq.)	Share of national total (%)	Change of emissions in agriculture during 1990–2005 (%)
Austria	7 854	6.3	–14.3
Czech Republic	7 738	5.3	–50.6
Germany	63 542	6.3	–18.2
Poland	32 157	8.8	–32.6

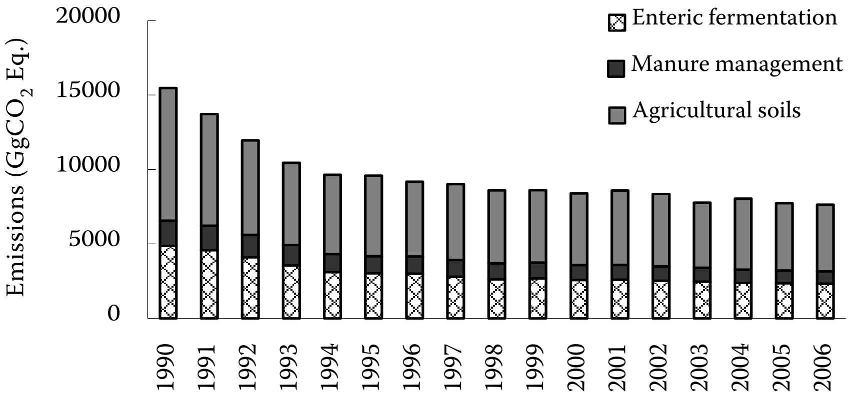

Figure 1. The emission trend in agricultural sector and contribution of the main emission categories during reporting period 1990–2006

for the sector of agriculture during the period 1990–2006 are shown in Figure 1.

For methane, the decrease in emissions for enteric fermentation since 1990 is linked to the animal population reduction, which applies specifically for cattle (from 3532 heads in 1990 to 1374 heads in 2006, e.g. ca 60% reduction). The decrease in emissions that originate from manure (especially swine manure) was not that big, which corresponds to a smaller decrease of swine population. The other contribution to the decreasing emission trends was the decline of amount of fertilizers applied in agricultural soils (from 418 kt of nitrogen in fertilizers in 1990 to 215 kt in 2006, e.g. more than 50% reduction) that results in N_2O emissions.

CH_4 emission from enteric fermentation of cattle dropped during the period of 1990–2006 from about 232 t CH_4 in 1990 to about one half (111 t CH_4) in the most recent years (Figure 2). This was mainly due to the considerable animal population decrease. It is obvious that enteric fermentation emission factors somewhat increased since 1990 because of the increasing cow weight and milk production and because of the increasing weight and daily weight gain for other cattle. CH_4 emission from cattle and swine manure management systems decreased during the reporting period from about 48 t CH_4 in 1990 to about 23 t CH_4 in 2006. The major sources of methane emissions are (i) enteric fermentation of cattle category and (ii) cattle and swine manure management systems.

Concerning N_2O emissions, the direct N_2O emissions counted about 55% (7.91 Gg N_2O), pasture manure 6% (0.85 Gg N_2O) and indirect emissions 39% (5.69 Gg N_2O) of total emissions in category of agricultural soils in 2006. The trend in N_2O emissions from agricultural soils is shown in Figure 3. From 1990 till 2006 the total emissions from agricultural soils decreased by 50% (rapidly during period 1990–1995, about 40%), direct emissions decreased by 46% and indirect emissions by 51%. More than 63% reduction was reached in the animal production.

In relation to the emissions generated in all other sectors, agriculture is the third largest sector in the Czech emission inventory with 8.1% of total GHG emissions in the base year 1990 and with 5.3% in 2006 (Figure 4). The share of CH_4 from enteric fermentation and manure management in the national total is about 23%, while the share of N_2O soil emissions and N_2O from manure management is about 65% in the national total – all in relation to the estimates for 2006.

Five of six relevant agricultural source categories were evaluated as the key categories. The over-

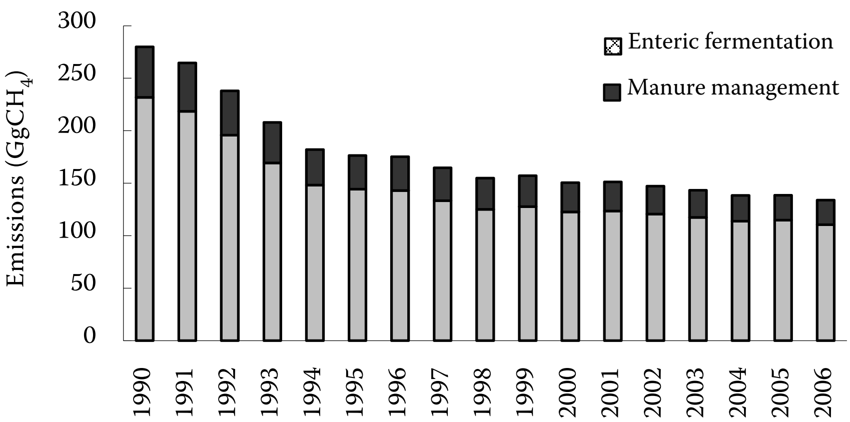

Figure 2. Emission trend of methane emissions including emissions from enteric fermentation and manure management during the time period 1990–2006

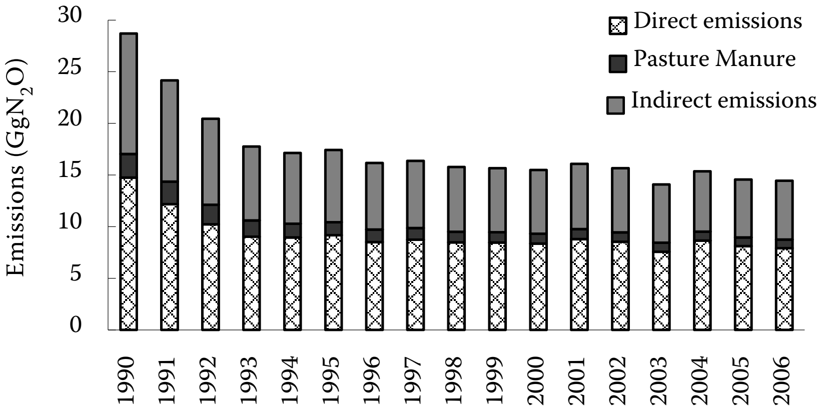

Figure 3. Emission trend of the category Agricultural soils and its components during the time period 1990–2006

view of these categories and their contribution to aggregate emissions is given in Table 3. The most important categories were those related to agricultural soils (direct and indirect sources) and enteric fermentation, with the contribution to total emissions of 1.7, 1.5, and 1.2%. Other categories are concerned in the national total emissions by less than 1%.

The emissions related to agriculture in the Czech Republic were compared to the neighbouring countries that have similar geographical conditions. We used the amount of agricultural emissions in 2005, the share of national total emissions in 2005, and the reduction of emissions in the time period 1990–2005 for Austria, the Czech Republic, Germany, and Poland (Table 4).

The GHG emissions from the agricultural sector in all selected countries decreased since the base year 1990, most significantly in the Czech Republic (–50.6%) and Poland (–32.6%). As for Austria and Germany, these countries had a developed market economy and significantly more advanced agricultural sector in 1990. The Czech Republic and Poland started its agricultural transformation in early 90's. Further changes were related to adoption of the agricultural policy of the European Union, when these countries became EU Members (in 2004).

The share of emissions from agricultural sector in relation to the total GHG emissions of selected countries (NIR 2007a, b, c, d) amounts from 5.3 to 8.8%. In all the countries, the reduction of emissions from agriculture is primarily due to the reductions in livestock populations (Myczko et al. 2001, Gebetsroither et al. 2002, Dämmgen et al. 2007). In addition, decreasing use of mineral fertilizers also contributed to the emission reduction in these countries in comparison to the level reported for 1990 (Strebl et al. 2002, Walczak 2003).

The agricultural sector is the second most vulnerable sector in the Czech Republic (UNFCCC 2005). The process of emission reduction in agriculture is slow and long-term. Currently, after a period characterized by large changes and development, the situation in agriculture is becoming more stable. Hence, it is reasonable to assume that the emissions in the near future should remain stable, with only small fluctuations.

The share of agricultural emissions on the national total of GHG emissions (5.3%) appears to be less important in the Czech Republic as compared to the other regions in Europe and overseas, for example,

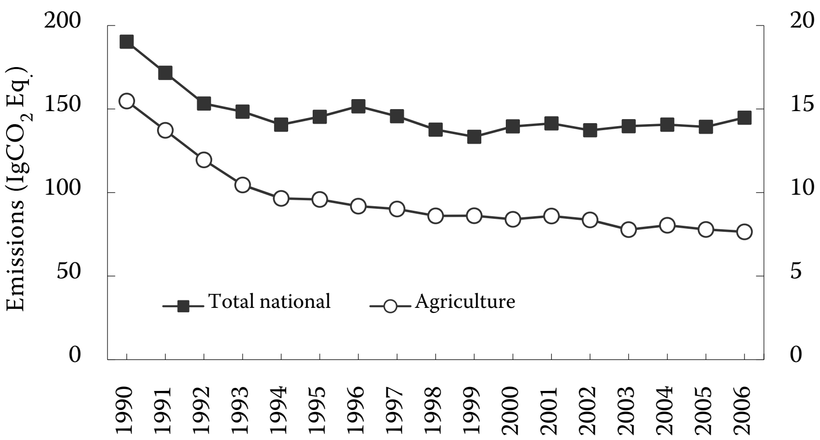

Figure 4. The total emissions of all sectors in the country (left axis) and the emissions estimated in agriculture (right axis) for the period 1990–2006

the GHG emission share of agriculture reached 9% in the European Union (as of 2005; www.unfccc.int). Somewhat more outdated information from China indicates an emission share of agriculture to be 15% (as of 1994), while it represents as much as 41% in Argentina (1997). Worldwide, the agricultural greenhouse gas emissions represent ca. 8% of the total GHG emissions (www.unfccc.int). This share is comparable to the emissions from the sector of industrial processes.

It is apparent that the reported shares of GHG emissions generated in agriculture remain high and hence it is important to consider possible and practicable measures to decrease them so that the sector contributes to the mitigation efforts made elsewhere. At the same time, the sector must consider adequate adaptation measures to tackle the expected impacts of climate change such as selection of suitable crops and management methods. The ability of agriculture to adapt depends on availability of resources, technologies, educational level, available information, management and infrastructure. It is obvious that the measures to be applied in agriculture should also be evaluated in terms of their impact to GHG emission balance.

REFERENCES

Dämmgen U., Lüttich M., Haenel H.D., Döhler H., Eurich M.B., Osterburg B. (2007): Calculations of Emissions from German Agriculture – National Emission Inventory Report (NIR) (2007 for 2005), Part 3, Methods and Data (GAS-EM). Landbauforschung Völkenrode, 304.

Gebetsroither E., Strebl F., Orthofer R. (2002): CH_4 Emissions from Enteric Fermentation in Austria, Seibersdorf Research Report ARC-S-0175, ARC, 38.

Hons P., Mudřík Z. (2003): Czech Country-Specific Data for Estimation of Methane Emissions from Enteric Fermentation of Cattle. AGROBIO Report for CHMI, Prague. (In Czech)

IPCC (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, NGGIP Publications, Vol. 1–3.

IPCC (2000): Good Practice Guidance and Uncertainty Management in National GHG Inventories, Chapter 4 – Agriculture. NGGIP Publications. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf

IPCC (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry. In: Penman J., Gytarsky M., Hiraishi T., Krug T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K. and Wagner F. (eds.). IPCC/OECD/IEA/IGES, Hayama, Japan.

IPCC 1997–2000 (2006) – Eggleston H.S., Buendia L., Miwa K., Ngara T., Tanabe K. (eds.): Intergovernmental Panel on Climate Change. Guidelines for National Greenhouse Gas Inventories. National Greenhouse Gas Inventories Programme, Vol. 1–5. IGES, Japan.

Jelínek A, Plíva P., Vostoupal B. (1996). Determining VOC emissions from agricultural activities in the Czech Republic. Report for CHMI. Research Institute of Agricultural Technology, Prague. (In Czech)

Kolář F., Havlíková M., Fott P. (2004): Recalculation of emission series of methane from enteric fermentation of cattle. Report of CHMI, Prague. (In Czech)

Mudřík Z., Havránek F. (2006): Czech country-specific data for estimation of methane emissions from enteric fermentation of cattle-updated data. Czech National Greenhouse Gas Inventory Report (2008), CHMI, Prague. (In Czech)

Myczko A., Karlowski J., Szulc R. (2001). Study on GHG from enteric fermentation and animal manure in 1999. Institute for Building Mechanization and Electrification of Agriculture, Warsaw. (In Polish)

NIR (2007a): National Inventory Report fo the Czech Republic, NIR (Reported Inventory 2005). Submission under the United Nations Framework Convention on Climate Change 2007, Czech Hydrometeorological Institute. Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php

NIR (2007b): The Australian Government Submission to the UN Framework Convention on Climate Change. National Inventory Report, Vienna. Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php

NIR (2007c): Poland's National Inventory Report 2005. Submission under the United Nations Framework Convention on Climate Change 2007. Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php

NIR (2007d): National Inventory Report for the German Greenhouse Gas Inventory 1990–2005, Submission under the United Nations Framework Convention on Climate Change 2007, Federal Environment Agency (Umweltbundesamt). Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php

Statistical Yearbook of the Czech Republic (1995–2006), Czech Statistical Office, Prague. (In Czech)

Strebl F., Gebetsroither E., Orthofer R. (2002): Greenhouse Gas Emissions from Agricultural Soils in Austria. Seibersdorf Research Report, ARCS-S-0176a, Seibersdorf.

UNFCCC (2005): Fourth National. Communication of the Czech Republic on the UN Framework Convention on Climate. Change and Demonstrable Progress Report on Implementation of the Kyoto Protocol. Ministry of the Environment of the Czech Republic. Available at: http://unfccc.int/resource/docs/natc/czenc4.pdf

Walczak J. (2003): Correction of N_2O emissions in 1988 and 1990–1998 in agriculture. In: Realization of Tasks of National Emission Centre in the emission inventory. Institute of Environmental Protection, Warszawa. (In Polish)

Received on July 18, 2008

Corresponding author:

Ing. Zuzana Exnerová, Ústav pro výzkum lesních ekosystémů, s.r.o., Areál 1. Jilovské a.s., 254 01 Jílové u Prahy, Česká Republika
e-mail: zuzana.exnerova@ifer.cz