EVALUATION OF MEASURES FOR MITIGATION OF GREENHOUSE GAS EMISSIONS SUITABLE FOR LATVIAN AGRICULTURE

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Abstract. It has been estimated that agricultural emissions from crop and livestock production grew from 4.7 billion tons of CO_2 equivalent in 2001 to over 5.3 billion tons in 2011, showing a 14 % increase and comprising almost 16 % of the total global anthropogenic emissions of GHG. This trend in agricultural GHG emissions is the response to global changes, such as population growth, diet change, that results in increased food demand. Without additional actions, GHG emissions in agriculture are projected to increase by 35-60 % up to 2030. However, in order to meet international commitments, management practices for reducing these emissions are required. Such global challenges in the sphere of climate change served as the basis for the research aim – to evaluate the measures for mitigation of GHG emissions suitable for Latvian agriculture. In order to meet the set aim, the research focuses on three key aspects: evaluation of the present situation in Latvia regarding GHG emissions in agriculture; theoretical review of mitigation methods; evaluation of the most prominent GHG mitigation measures for Latvian agriculture. The research results showed that many agricultural practices can potentially mitigate GHG emissions through different mechanisms and could be potentially introduced in Latvian agriculture.

Keywords: GHG, emissions, mitigation, measures, Latvia.

Introduction

Climate change is one of the defining challenges of the 21st century, along with the global population, poverty alleviation, environmental degradation and global security [1]. There is strong scientific evidence which shows that the current climate change is caused largely by the increased concentration of carbon dioxide (CO_2) in the atmosphere emitted through human activities [2; 3]. It has been estimated that human activities currently release over 30 billion tons of CO_2 into the atmosphere every year [1], and agricultural activities are one of the major greenhouse gas (GHG) emitters behind such sectors as transport and industrial processes [4].

The Food and Agriculture Organization of the United Nations (FAO) estimates of GHG data show that agricultural emissions from crop and livestock production grew from 4.7 billion tons of CO_2 equivalents in 2001 to over 5.3 billion tons in 2011, showing a 14 % increase [5] and comprising almost 16 % of the total global anthropogenic emissions of GHG [6]. These trends in agricultural GHG emissions are the response to global changes, such as population growth, diet change, that results in increased food demand [7]. It has been projected that without additional policies, agricultural GHG (i.e. nitrous oxide N_2O and methane CH_4) emissions are projected to increase by 35-60 % and ≈ 60 %, respectively, up to 2030 [8].

Agricultural GHG emissions are complex and heterogeneous, but active management of agricultural systems and emerging technologies offers possibilities for GHG emissions mitigation [9]. Thus agriculture holds a large potential for climate change mitigation.

Such global challenges in the sphere of climate change served as the basis for the research aim – to evaluate measures for mitigation of GHG emissions suitable for Latvian agriculture. In order to meet the set aim, the following research objectives were defined: to evaluate the present situation in Latvia regarding agricultural GHG emissions; to give a theoretical review of GHG mitigation methods; and to distinguish the most prominent GHG mitigation measures for Latvian agriculture.

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Materials and methods

To achieve the set aim and tasks of the research, the authors have used the publications and studies of Latvian and foreign scientists; statistical data from the European Environment Agency that covers twenty-two years in the time period from 1990 till 2012.

In order to study the problem elements the authors have widely applied several research methods:

- to find out the real situation in Latvia regarding agricultural GHG emissions general scientific methods (analysis and synthesis, monographic) and statistical research methods (calculating statistical indicators, data generalization) were used;
- to give a theoretical review of GHG mitigation methods and to distinguish the most prominent GHG mitigation measures for Latvian agriculture general scientific research methods were used – monographic method, analysis and synthesis, induction and deduction.

Results and discussion

Agricultural GHG emissions – situation in Latvia

Since 1990 Latvia has been actively participating in the global climate change mitigation process. In the context of GHG there are two sets of targets to be achieved: 1) the Kyoto Protocol targets for the period 2008-2012 and 2) the 2020 targets for emissions not covered by the EU emission trading system (ETS) [10]. Under the Kyoto Protocol the emission reduction target for Latvia for the period 2008-2012 has been set to minus 8 % based on 1990 for GHG emissions (CO_2 equivalent). An evaluation of the latest data (Table 1) indicate that Latvia's agricultural CH_4 and N_2O emissions in 2012 were almost 2.5 times lower than in 1990, reflecting the economic transition in the early 1990s driven by the transition to a market economy when agricultural activity slowed down and the reduction of crop and livestock production took place. Therefore, with the first target Latvia has coped successfully.

However, in recent years, the situation regarding agricultural activity has changed due to support provided by the Rural Development Plan and national subsidies to farmers, thereby since 2001 the Latvian agricultural GHG emissions have show a growing trend. In Latvia agriculture contributed to about 22 % of the total GHG emissions in CO_2 equivalent in 2012, which was the third highest contribution from agriculture among the European Union (EU) Member States. Due to increased agricultural activity, agricultural GHG emissions increased by 98 Gg CO_2 eq, comprising a 4.3 % increase in 2012 if compared with 2011.

The GHG inventory results [9] show that there can be defined three principle sources of agricultural GHG emissions in Latvia - N_2O direct emissions from agricultural soils; CH_4 emissions from cattle enteric fermentation in the digestive tract; and indirect N_2O emissions from agricultural soils – that show growing trends (Table 1).

Table 1

Total agricultural GHG emissions and GHG emission division by sources (Gg CO_2 eq) and the share of agricultural GHG in the total GHG emissions (%) in Latvia in 1990, 2011 and 2012

Agricultural GHG emission source	1990	2011	2012
Enteric fermentation – cattle (CH_4 emissions, Gg CO_2 eq)	2 065	637	657
Enteric fermentation – sheep (CH_4 emissions, Gg CO_2 eq)	28	13	14
Manure management – cattle (CH_4 emissions, Gg CO_2 eq)	67	54	58
Manure management – swine (CH_4 emissions, Gg CO_2 eq)	118	32	30
Manure management – solid storage and dry lot (N_2O emissions, Gg CO_2 eq)	564	118	118
Agricultural soils – direct emissions (N_2O emissions, Gg CO_2 eq)	1619	962	1011
Agricultural soils – pasture, range and paddock manure (N_2O emissions, Gg CO_2 eq)	358	87	88
Agricultural soils – indirect emissions (N_2O emissions, Gg CO_2 eq)	1034	389	414
Total GHG emissions from agriculture (Gg CO_2 eq)	5 853	2 292	2 390
Share of agricultural GHG from total GHG emissions (%)	22.51	20.84	21.73

Source: authors' calculations based on [9]

According to the Kyoto Protocol target for the second commitment period, by 2020 Latvia can increase its emissions not covered by the EU ETS by 17 %, compared with 2005, according to the Effort Sharing Decision. However, national projections show that Latvia is expected to increase its emissions not covered by the EU ETS by 18 %, compared with 2005, in scenarios with the existing measures, thus not meeting its 2020 target [10]. Therefore, in order to ensure that Latvia will be able to meet its international commitments, sustainable management practices for reducing GHG from agriculture need to be developed and adopted. Special focus should be paid to such management practices that tend to mitigate CH_4 emissions from cattle enteric fermentation, N_2O direct emissions from agricultural soils and indirect N_2O emissions from agricultural soils, which currently are the main sources of agricultural GHG emissions in Latvia.

Theoretical review of GHG emissions mitigation methods

Agricultural measures aimed at improving management practices, including environmental benefits – reductions of GHG emissions – are known as beneficial management practices (BMP). The classifications of BMPs are different. P. Smith with co-authors [11] associates the opportunities for reducing GHG emissions with three mechanisms.

- Reducing emissions – the mechanism relates to more efficient management practices to reduce GHG emission.
- Enhancing removals – the mechanism relates to reducing the loss of carbon accumulated in soil humus. In practice, these are land management solutions that increase the amount of carbon absorbed in photosynthesis and prevent the absorbed carbon from getting into atmosphere.
- Avoiding (or displacing) emissions: the mechanisms relate to the use of plant and agricultural residues in energy production, for instance, biogas, ethanol or biodiesel fuel.

The classification of BMPs by management pathway is the most popular; according to the EP Directorate-General for Internal Policies supported document „Measures at Farm Level to Reduce Greenhouse Gas Emissions from EU Agriculture" [12], BMPs may be classified into:

- agronomic measures – nitrogen balance, introduction of leguminous plants on arable land, conservation agriculture, cover crops;
- livestock measures – manure storage, manure spreading, biogas;
- energy measures – biomass, photovoltaic, fuel reduction, electricity reduction;
- agri-environmental measures (AEM) – low carbon AEM.

Asgedom and Kebreab [13] have based their classification on three large groups in which energy or AEM measures are not analysed by researchers:

- crop production – inorganic N fertilizers, cropping systems;
- animal production – feeding, pasture management;
- manure/Soil – manure management, including biogas.

It was found that whilst supply-side mitigation measures, such as changes in land management, might either enhance or negatively impact food security, demand-side mitigation measures, such as reduced waste or demand for livestock products, should benefit both food security and GHG mitigation [8].

Although BMPs globally recognized as one of the most efficient approaches for GHG emissions mitigation, these practices are diverse and the practical choice of them is determined by the current government policies and support instruments, the specifics of agricultural practices and the climatic and geographic conditions.

However, the classification issue is important in the context of constructing a marginal abatement costs curve (MACC), which represents either the marginal loss in profits from avoiding the last unit of emissions or the marginal cost of achieving a certain emission target given some level of output [14]. The introduction of a certain measure may also affect the effectiveness of other measures or there is mutual interaction among them. This reason is important to avoid counting up the effects of a measure many times or because with one measure introduced, the other ones might lose their potential.

Evaluation of potential GHG emissions mitigation measures for Latvian agriculture

An evaluation of BMPs involves two key characteristics: measure introduction cost per unit of emissions and GHG emission reduction potential, which shapes a MACC. Yet, the measures to be introduced may be characterised by a great diversity, which are mostly the policies and support programmes implemented in the territory, agricultural industries, production practices, climatic and geographic conditions, as well as other factors. There are also great differences in performance results, which are mostly determined by economic disparities, production practices and the account methodology. At the same time, other characteristics are employed to evaluate the potential BMPs [12]. A theoretical overview on beneficial agricultural management practices, their reduction potential, implementation costs, concerned farming systems and implementation difficulty for farmers are summarized in Table 2. Information summarized in Table 2 lets the authors to conclude that potential GHG emission mitigation measures suitable for Latvian agriculture could be as follows – nitrogen balance, introduction of leguminous plants on arable land, extended grazing season, feeding strategies, biogas production.

Table 2

Theoretical overview on beneficial agricultural management practices, their reduction potential, implementation costs, concerned farming systems and implementation difficulty for farmers

Measure	GHG emission reduction potential	GHG emission reduction per unit	Implementation costs	Farming system concerned	Difficulty for farmers
Nitrogen balance	High	0.34[a] t CO_2 eq·(ha·y)$^{-1}$	Neutral/negative (-15-0 EUR·ha^{-1})	All, except greenhouse	Easy
Introduction of leguminous plants on arable land	Medium	0.56[a] t CO_2 eq·(ha·y)$^{-1}$	Low/neutral (1.32 t CO_2 (ha·y) $^{-1}$	Arable land	Medium
Cover crops	High	1.78 t CO_2eq·y^{-1}	Low/medium (71.20 EUR·ha^{-1})	Cropland	Medium/ high
		0.49 t CO_2 CO_2eq·y^{-1}			
Manure storage	Low	Reduction of NH_3 emissions by 70-90 %	Low (60-200 EUR·m^{-2})	Livestock, especially pigs and cattle	Easy
		0.69 t CO_2 eq·(m_{manure})$^{-3}$	4.24 EUR·t^{-1}		
Manure spreading	Low	Drip hose system - 55 % NH_3 emissions	1 200 EUR·m^{-1}	Livestock, especially pigs and cattle	Easy
		Injection in to the soil -95 % NH_3 emissions	1.28 EUR·m^{-3}		
Extended grazing season	Medium	-	-3.24 EUR per cow	Livestock	Easy
Feeding strategies	High	Up to 50 % reduction compared with mature pasture	57-282 USD·t^{-1} CO_2 eq	Livestock	High
			-0.004 EUR·kg^{-1} carcass		
Biogas	High	1.5 t CO_2 eq·(kW·y)$^{-1}$	Medium/high 5 000-10 000 EUR·kW^{-1}	Livestock	High
Biomass	Low	3 kg CO_2 eq·l^{-1} gaseous fuel	Medium	All farms	Medium
Fuel reduction	Medium	0.27 t CO_2·(t·y)$^{-1}$	Low	All farms	Easy
Electricity reduction	Low	-	Low	Dairy, cold rooms, irrigation	Easy

Source: authors' summarization based on [12; 13; 15; 16]

Every research study presents a number of various GHG emission reduction measures that are aggregated into groups for illustrative purposes. For instance, the project Baltic Deal – Putting Best

Agricultural Practices into Work provides the descriptions of 60 GHG emission reduction measures that are grouped into 8 groups; however, they are mainly modifications of quite similar measures, which prevents from expressing unbiased performance results [17]. It has to be noted that it is one of the first research studies in which Latvian farmers have participated in evaluation. In general, the interest of both scientists and practitioners in GHG emission reduction measures appropriate for Latvia's conditions increases fast in Latvia. The first recommendations for reducing GHG emissions in Latvia have been developed [18]; yet, the most important conclusion is that there is a lack of information and research studies allowing developing specific and precise BMPs for Latvia's conditions. Presently, several projects are being implemented that are aimed at analysing the effects of agricultural production on GHG emissions emergence and at developing BMPs for Latvia. Latvia's scientists have summarised information on the cultivation of leguminous crops for the purpose of reducing environmental risks [19], the emissions in the agricultural industry and their reduction possibilities [20; 21], as well as on many other issues. The research studies started allow hoping that in the nearest future scientifically justified BMPs for Latvia's farmers and clear policy priorities in agriculture and environmental protection will be available.

Conclusions

1. In Latvia agriculture contributes about 22 % of total GHG emissions in CO_2 equivalents in 2012 and due to increased agricultural activity Latvian agricultural GHG emissions show a growing trend, i.e. in 2012 the amount of agricultural GHG emissions increased by 4.3 % if compared with 2011.
2. In order to ensure that Latvia will be able to meet the Kyoto Protocol target for the second commitment period, sustainable management practices for reducing GHG from agriculture need to be developed and adopted. Special focus should be paid on such management practices that tend to mitigate CH_4 emissions from cattle enteric fermentation, N_2O direct emissions from agricultural soils and indirect N_2O emissions from agricultural soils, which currently are the main sources of agricultural GHG emissions in Latvia.
3. One of the most efficient and globally recognized approaches for GHG emission mitigation is beneficial management practices. The practices are diverse and the practical choice of them is determined by the current government policies and support instruments, the specifics of agricultural practices and the climatic and geographic conditions.
4. Theoretical overview on beneficial agricultural management practices, their reduction potential, implementation costs, concerned farming systems and implementation difficulty for farmers indicate that potential GHG emission mitigation measures for Latvian agriculture could be as follows – nitrogen balance, introduction of leguminous plants on arable land, extended grazing season, feeding strategies, biogas production.

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