GREENHOUSE GAS EMISSIONS AND MITIGATION OF LAND-USE, LAND-USE CHANGE AND FORESTRY (LULUCF)

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Abstract
Climate change is supposed to increase continental and sea temperatures, alters precipitation quantity and patterns, resulting in the increase of global average sea level and an expected increase in the severity of weather-related natural disasters. Addressing climate change requires two types of response. Countries must reduce greenhouse gas (GHG) emission by taking mitigation and adaptation action to deal with the unavoidable impacts. Similar to mitigation activities, the integration of environmental concerns into the Common Agricultural Policy (CAP) is based on a distinction between ensuring a sustainable way of farming by avoiding harmful activities and providing incentives for public goods and services. The common rules and standards are mandatory for farmers to ensure that agricultural activity is undertaken in a sustainable way and preserve environment and the landscape. These rules and standards form the reference level to which the costs for complying with these obligations have to be born by the farmer, according to the "Polluter-Pays-Principle". The Common Agricultural Policy ensures that farming and preservation of the environment go hand-in-hand and plays a vital role in confronting new challenges such as biodiversity, water management and climate change. There are large regional differences in mitigation potential and in the costs and benefits of mitigation options. It is necessary to tailor policy measures to specific conditions of farming. The Europe 2020 strategy puts innovation and green growth at the heart of its blueprint for competitiveness, and proposes tighter monitoring of national reform programmes to get out of the crisis and to prepare the foundation for the EU economy for the next decade.

Key words*: Climate change, GHG emissions from agricultural soils, mitigation*

INTRODUCTION

In most agricultural soils, mineral nitrogen enhances microbiological formation of N_2O, which in turn increases nitrification and denitrification rates. The methodology to calculate greenhouse gas emissions from agricultural soils are based on data available from FAO database and the methodology does not take into account different crops, soils and climates, which are known to regulate N_2O production. Because of limited data availability to provide appropriate emission, these factors are generally not considered. Countries, which have data to show that default data are inappropriate for their country, should include a full explanation for the values used. The IPCC method also uses a linear extrapolation between N_2O emissions and fertiliser nitrogen application. The changes in carbon stocks can be estimated by establishing rates of change in land use. Although there are CORINE data on which land-use change estimates, the rates of change in land use are difficult to establish. A more practical approach is to make simple assumptions about the effects of land-use change on carbon stocks and the subsequent biological response to the land-use change, and to use these assumptions to calculate carbon stock changes and hence the CO_2 flux (Friedlingstein et al. 2001). IPCC method also addresses the immediate release of CH_4, CO, N_2O and NO_x from the open burning of biomass after forest clearing.

MATERIALS AND METHODS

Emissions of N_2O from agricultural soils are closely related to the nitrogen balance and IPCC methodology is used to calculate the N_2O emission. The amount of nitrogen (N) applied on soil by use of synthetic fertiliser, manure applied to soil, N-fixing crops and crop residue contribute directly to emissions of greenhouse gases. Carbon dioxide emissions from soils are described in the section of land-use, land-use change and forestry (LULUCF). Paper is based on National Inventory Report (NIR) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) and contains national greenhouse gas emission estimates for the period 1990 to 2007. The estimation is compiled in accordance with the Inventory Reporting Guidelines agreed by the UNFCCC Conference, and set out in document IPCC Reference Manual (IPCC, 1995) and the Good Practice Guidance (IPCC, 2001). Data are from the European Environment Agency (dataservice.eea.europa.eu). Member states emissions data are compared on CO_2 equivalence bases calculated total emission per capita.

GREENHOUSE GAS EMISSIONS FROM AGRICULTURAL SOILS

Agricultural soils may also emit or remove nitrous oxide (N_2O), carbon dioxide (CO_2), and/or methane (CH_4). The method for calculating national emissions of agriculture soils are described in IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1995). In the methodology two sources of nitrous oxide are distinguished; (i) direct emissions from agricultural soils, and (ii) nitrous oxide emissions induced indirectly by agricultural activities. Anthropogenic input include synthetic fertiliser, nitrogen from animal wastes, nitrogen from increased biological N-fixation, and nitrogen derived from cultivation of mineral and organic soils, through enhanced organic matter mineralisation. Nitrous oxide may be produced and emitted directly in agricultural fields, animal confinements or pastoral systems or be transported from agricultural systems into ground and surface waters through surface runoff, nitrogen leaching. In some cases, human sewage systems also transport the nitrogen into surface water. Ammonia and NO_x emitted from soil may be transported and fertilise other systems, which leads to enhanced production of N_2O.

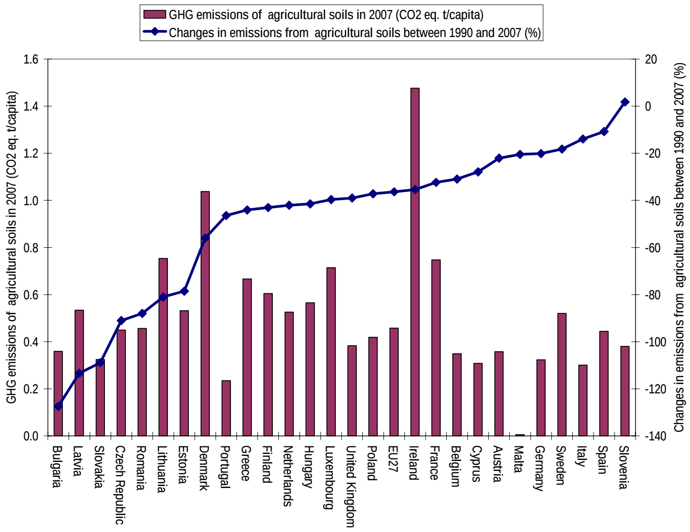

Fig.1: GHG emissions of agricultural soils in 2007 (CO_2 eq. t/capita) and changes in emissions between 1990 and 2007 (%) (Data are from dataservice.eea.europa.eu)

The amount of synthetic fertiliser nitrogen applied to soil is well documented in the FAO Annual Fertiliser Yearbook, but factors are needed to account for the loss of fertiliser in from of NH_3 volatilisation and emission of nitric oxide. The IPCC methodology for assessing direct N_2O emissions includes consideration of synthetic fertiliser, nitrogen from animal waste, enhanced N_2O production due to biological N-fixation, nitrogen from crop residue mineralisation and soil nitrogen mineralisation due to cultivation of Histosols (IPCC 2001). Significant amounts of CO_2 can be removed from the atmosphere and stored in soils through a range of farming practices, such as organic farming; zero or reduced tillage systems that avoid or reduce soil disturbance; growing protein crops; planting hedgerows; maintenance of permanent pastures and conversion of arable land to grassland. Significant amounts of carbon can be removed with afforestation, as woody species hold much more carbon than most agricultural crops.

In the period of 1990-2007, methane and nitrous oxide emissions from agricultural soils decreased by 36.4% in EU-27 countries, which represent 0.457 tons CO_2 eq. per capita. There are considerable variations in emissions from agricultural soils between countries of EU (Figure 1). Large reductions occurred in Bulgaria, Latvia, Slovakia, Czech Republic, Romania, Lithuania and Estonia, while Slovenia increased GHG emission from agriculture soils between 1990 and 2007. In 2007, per capita GHG emission of agricultural soils ware highest in Ireland and Denmark. Reduction in GHG emission was very fast between 1990 and 1993, mostly as results of transition in East European countries (CEC 2009, 2010). The contribution of EU-15 member states countries to the GHG emission of EU increased until 2001 (Figure 2).

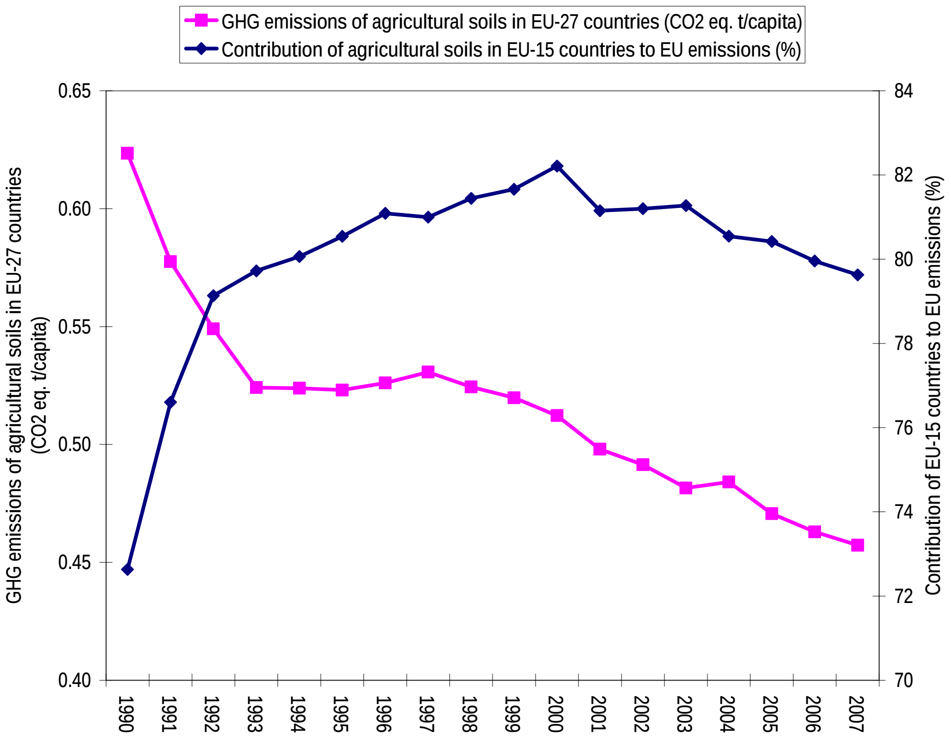

Figure 2: GHG emissions of agricultural soils in EU-27 countries (CO_2 eq. t/capita) and contribution of EU-15 countries to EU emissions (%) (dataservice.eea.europa.eu)

LAND-USE, LAND-USE CHANGE AND FORESTRY

Human activities, which change the way land is used, such as clearing of forests for agricultural use affect the amount of CO_2 stored in biomass and soil. This mitigation potential is a focal point of calculating greenhouse gas emissions. The biosphere is a strong determinant of the chemical composition of the atmosphere and it has been true since the existence of the biosphere, when a large amount of carbon, nitrogen, and sulphur gases was absorbed. There is strong evidence that the expanding human use of the biosphere for food, fuel and fibre is contributing to increasing atmospheric concentrations of greenhouse gases. Estimates of CO_2 emissions due to land-use change vary considerably because of diversified human activity. According to IPCC Guidelines for National Greenhouse Gas Inventories, the fundamental basis for the methodology rest upon two linked themes (IPCC, 2001). The flux of CO_2 to or from the atmosphere is equal to changes in carbon stocks in the biomass and soils.

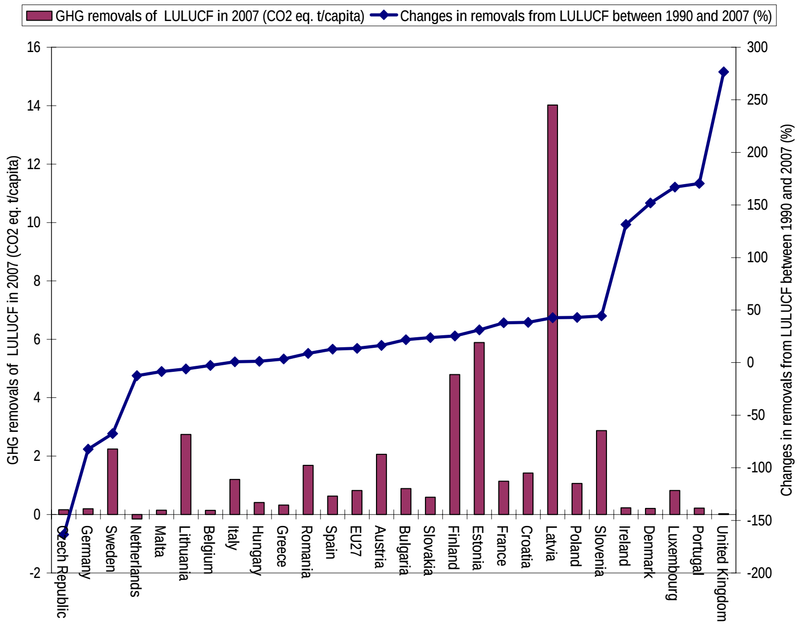

Figure 3: GHG removals of LULUCF in 2007 (CO_2 eq. t/capita) and changes in removals between 1990 and 2007 (%) (Data are from dataservice.eea.europa.eu)

In the period of 1990-2007, GHG removals of LULUCF increased by 13.6% in EU-27 countries, which represent 0.822 tons CO_2 eq. per capita, although there are considerable variations between countries (Figure 3). Large removals from LULUCF occurred in Austria, Sweden, Lithuania, Slovenia, Finland, Estonia and Latvia, while between 1990 and 2007, Netherlands increased GHG emission from LULUCF. In 2007, Per capita GHG removal of LULUCF was highest in Latvia and removed more CO_2 than the total GHG emission of the country. Mostly as result of transition in East European countries, reduction in GHG emission was very fast between 1990 and 1994. The contribution of EU-15 member states countries to the GHG emission of EU increased until 2000 (Figure 4).

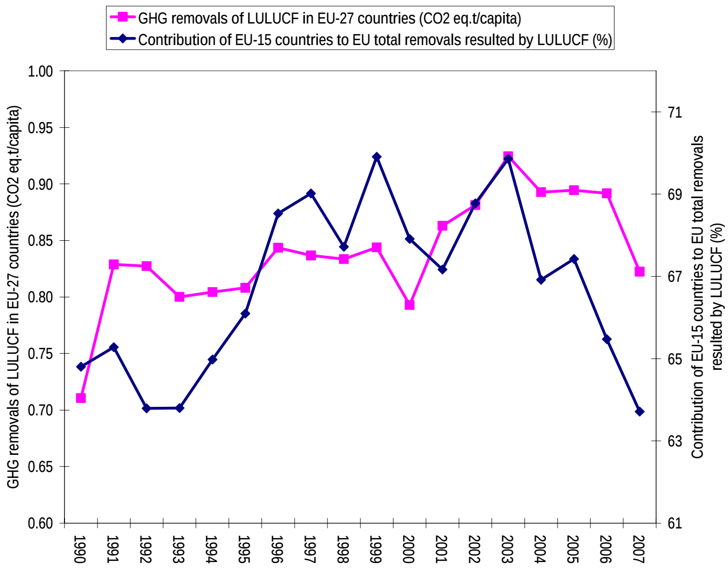

Figure 4: GHG removals of LULUCF in EU-27 countries (CO_2 eq. t/capita) and contribution of EU-15 countries to EU removals (%) (dataservice.eea.europa.eu)

The estimate of CO_2 fluxes is based on inventorying the areas and C stocks for land-use systems predominating within a particular climatic region. The most significant practices that differentiate land-use and management systems are clearing of native vegetation with conversion to cultivated crops or pasture; land abandonment; shifting cultivation; differing residue addition levels; differing tillage systems; and agricultural use of organic soils. According to IPCC Guidelines for National Greenhouse Gas Inventories, the most important land-use changes that result in CO_2 emissions and removals are:

- changes in forest and other woody biomass stocks: the most important effects of human interactions with existing forests includes commercial management, harvest of industrial round wood and fuel wood, production and use of wood commodities;
- forest and grassland conversion: the conversion of forests and grasslands to pasture, cropland, or other managed uses can significantly change carbon stored in vegetation and soil;
- abandonment of croplands, pastures, plantation forests, or other managed lands, which regrow into their prior natural grassland or forest conditions.
- changes in soil carbon: In most cases, land that has been cultivated for many years is depleted in organic matter relative to its original state. In the temperate zone, considerable areas of formerly cultivated lands have been abandoned or converted to grassland and forest. If converted to perennial vegetation, either through land abandonment and natural succession or as an active management decision, such as conversion to pasture and conservation practices, soil carbon levels generally increase.

Intensive soil tillage is recognised as a significant factor causing soil organic matter declines in cultivated soils (Reilly, 2002). Intensive tillage enhances decomposition of organic matter and supply crops with plant nutrients. Reduced tillage and particularly no-till practices have been shown to promote higher levels of organic matter in many regions, where productivity and organic matter inputs are not adversely related. Reduced soil erosion and lower soil temperatures under surface mulches are particularly important attributes of no-till systems. Maintenance of soil carbon also depends on an adequate return of organic substrates, which serve as the raw material for organic matter formation. In most agricultural systems, the primary sources of new carbon are crop residues.

The amount of carbon returned in the form of residues depends on the total biomass yield and the proportion of that biomass, which is exported from the field. Of the carbon applied to soil in the form of crop residues, about one third typically remains after one year and about one-fifth remains after five years under temperate conditions. The remainder is returned to the atmosphere as CO_2 via biological decomposition. The rate of decomposition, and the proportion of carbon retained by soil, is influenced by climate, soil conditions, placement (surface versus buried), and the composition of the residue. Some agricultural soils also receive significant inputs in the form of vegetation grown, at least in part, to provide additional carbon and other nutrients to the soil. For example, legumes are sometimes included in cropping systems as a 'green manure'. Similar benefits are derived from vegetative additions in 'alley-cropping' systems. A third source of carbon is various by-products, which are applied as soil amendments. The most noteworthy of these are animal manure, but some soils also derive appreciable carbon inputs from sewage sludge. Although such additions can significantly increase soil carbon, gains in the soil must be compared with alternative uses of the resources. For example, if sewage sludge decomposes more rapidly in soil than in fermented form to produce biogas, the net effect will be an additional flux of carbon to the atmosphere.

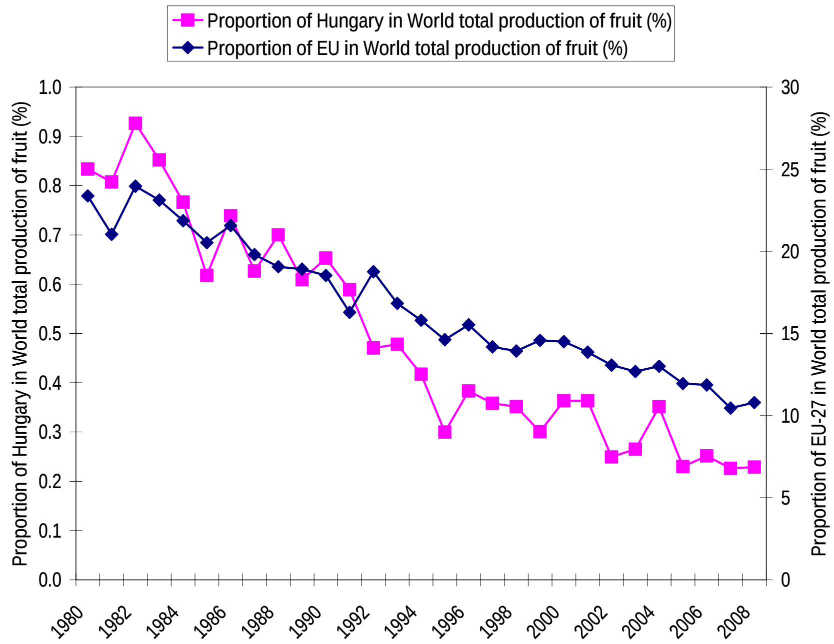

Figure 5: Contribution of Hungary and EU-27 countries to World total production of fruit

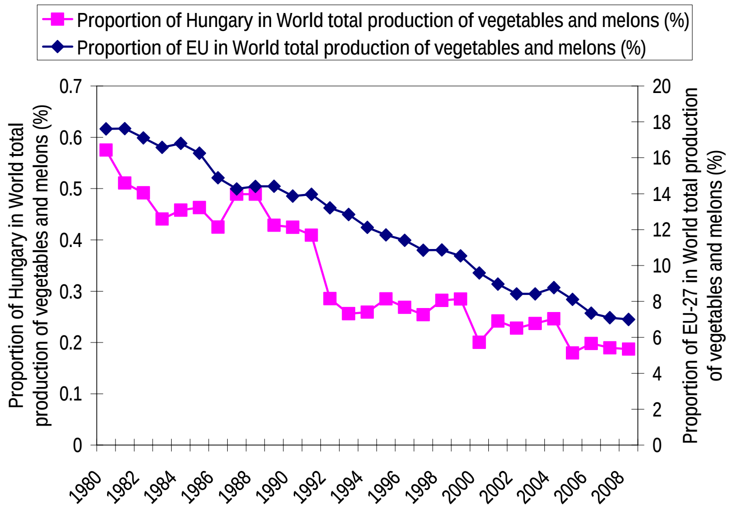

Figure 6: Contribution of Hungary and EU-27 countries to World total production of vegetables and melons

DISCUSSIONS

According to FAO statistics, EU-27 countries produced 23.4% of total world fruit production in 1980 and this has reduced to 10.8% in 2008 (Figure 5). Contribution of EU countries to World total production of vegetables and melons was close to 17.65% at the beginning of the 1980s and now it is less than 7% (Figure 6). Hungary produced more than 0.57% of vegetables and melons. This number has reduced to 0.18%. According to FAO statistics, Hungary produced 0.83% of total fruit production in 1980 and this has reduced to 0.23% in 2008. To ensure adequate food supplies, produce row material for industry and energy sector, preserve the countryside and provide a reasonable living for agricultural and related populations we need Europe 2020 strategy focused on smart growth to foster knowledge, innovation and education in agriculture, where the employment rate is low and the acquisition of skills to fight against poverty is difficult. Agriculture also has further possibilities to reduce the emissions of methane, nitrous oxide and carbon dioxide released by farming activities and by maintaining and sequestering carbon in farmland soils. There are management options that have the potential to reduce methane and nitrous oxide emissions below current levels. These include the reduction in use of fertiliser and agricultural input, livestock and manure management. Precision farming, optimisation of mineral and organic nitrogen application and overall reduction of external inputs (e.g. in organic farming) also contributes to the reduction of GHG emissions. Production of mineral fertilisers and other chemical products is energy intensive. GHG emission of ammonia production in EU-27 countries was 0.056 tons CO_2 eq. per capita in 2007.

Extensive forms of pasture management in livestock rearing, technical additives to control methane from digestion processes and improvements in the nutrition patterns (diet and the level of food intake) of livestock influence the amount of methane releases from enteric fermentation and manure management. Less intensive forms of rearing are beneficial for landscape conservation and bio-diversity. Improved manure storage, such as appropriate installations for different types of animal manure and slurry, application of immediate incorporation into soils and better accounting of nitrogen content can contribute to the reduction of GHG emissions. Processing of animal waste in anaerobic digestion plants for the production of biogas has been identified as one of the most promising measures and is highly cost-effective in farms with high animal densities and large volumes of slurry and manure. These technical and management options vary in cost-effectiveness. One of the best practices is improved storage of manure and the accounting of its nitrogen content when applied to the fields. The costs and benefits of agricultural mitigation options are diverse. Regional differences are influenced by a number of factors such as farm characteristics (size, location, yields, level of inputs), climatic and environmental conditions (land and soil characteristics, water availability), the degree to which mitigation measures compete with traditional agricultural practices and profitability, and the incentives in place such as financial support.

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