PROMOTION OF GRASSLAND AS STRATEGY TO REDUCE GREENHOUSE GAS EMISSION: RESULTS FOR SPAIN OF THE EU-WIDE ANALYSIS WITH THE CENTURY AND THE CAPRI MODELS

Espinosa, M.*[a], Gocht, A.[b], Schroeder, L.A.[b], Leip, A.[c], Gómez y Paloma, S.[a], Lugato, E.[c], van Doorslaer, B.[a], Salputra, G.[a]

[a] *European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Agrilife Unit, (Sevilla, Spain). Maria.espinosa@ec.europa.eu*
[b] *Thünen-Institut for Rural Studies (TI), (Braunschweig , Germany).*
[c] *European Commission, Joint Research Centre, Institute for Environment and Sustainability, (Ispra, Italy).*

ABSTRACT: We assessed the economic, land use and GHG emission effects of an expansion in the grassland area by 5% relative to its baseline level in 2020 using the CAPRI-FT and CENTURY models. Carbon sequestration rates were region and farm-type dependent and summed up to a total carbon sequestration in Spain of 859 kt CO_2/yr. Largest increases in carbon sequestration were obtained for extensive livestock and crop farming systems in extensive regions (Castilla-Leon, Andalucia and Castilla-La Mancha). The calculated premium associated to grassland so that farmers convert voluntary to grassland is EUR 138/ha converted. Considering that permanent grassland has to be maintained for a period of at least 5 years (e.g. in the framework of agri-environment schemes), this corresponded to an abatement cost of EUR 10 per ton of CO_2 sequestered in the soil (considering that the premium is paid once). This was about twice as high than the current average price of the EU allowance of EUR 4.43/ton CO_2. However, societal benefits of grassland expansion on the provision of public goods such as biodiversity were not included in these simulated values.

KEY WORDS: *Grassland, greenhouse gass emission, CAPRI model.*

1. INTRODUCTION AND OBJECTIVES

Agricultural soils play a major role with regard to greenhouse gas emissions and removals because they contain a large stock of terrestrial carbon in the form of soil organic matter. To protect this carbon pool, the European Union (EU) has introduced as the *greening* measure in the CAP-post 2013 to maintain the ratio of permanent pasture to arable cropping systems. In addition, the roadmap for moving to a low–carbon economy (EC, 2011) identified maintaining and enhancing Soil Organic Carbon (SOC) levels across the EU by 2020 as a key goal.

Given this background, we developed and assessed a scenario of a politically induced EU- wide farmer's production adjustment which increases the grassland area by 5% in the EU27. Our aim is to quantify the additional amount of carbon that could be sequestered and the implication on farmer's economic situation and social costs that such a measure would have. The analysis was done on the basis of the 2,500 agricultural farm supply models of the CAPRI model using region-specific carbon (C) sequestration rates. The C sequestration rates were obtained from simulations with the biogeochemistry CENTURY model, spatially applied with consistent European soil, climate and land use/management datasets. The linkage between the CENTURY and CAPRI farm model was achieved by converting the carbon sequestration rates derived from the CENTURY model (at NUTS3 level) to the farm- types rates needed for the CAPRI-farm model. To approximate the location of a farm type, which is a combination of the farm specialisation and the farm size in a NUTS2 region we have used the FADN data base. We calculated, based on the FADN sample, a probability matrix which defines how likely a specific farm specialisation and farm size is located in a certain NUTS 3 region.

To our knowledge, this is this first EU wide application in which spatial specific CO_2 sequestration rates for grassland at high resolution were calculated explicitly for different farm groups. We discuss the distribution of costs for CO_2 sequestration and compare the findings with results from other GHG abatement measures in agriculture. The analysis has been conducted at EU wide level; however in this communication we will just focused in Spain.

2. METHODOLOGY

The models used are described in depth in the literature. Due to size restrictions of the communication we refer the interested reader to Gocht *et al.* (2013) and Gocht and Britz (2011) for CAPRI-FT and Lugato *et al.* (2014) for a description of CENTURY.

The CENTURY and CAPRI-FT scenario settings and assumptions are summarized in Table 1. The CAPRI-FT baseline is a business as usual simulation for the year 2020, while in the 'greening' scenario a 5% increase of grassland compared to the baseline is imposed at NUTS2 level, equivalent to a command and control measure. CAPRI-FT runs at NUTS2 and FT level for the simulation year 2020. CAPRI-FT evaluates the differences (in area, income,…) between the scenario and the baseline in the year 2020.

Table 1. Scenario settings.

	CENTURY		CAPRI-farm type	
	Base year	Scenario	Baseline	Scenario
Scenario type	Business as usual based on the current management and practices	na	Business as usual[c]	Command and control
Land conversion target value	na	100 % conversion of arable land to grassland[b]	n.a.	Increase of grassland by 5% compared to baseline
Target achieved at	na	na	n.a.	NUTS2 level
Analysis	SCL[a]	SCL[a]	NUTS2 & Farm type level	NUTS2 & Farm type level
Simulation year	2013	2020	2020	2020
Results		SOC change at SCL level/year.ha		Differences (in area, income…) between the baseline and the scenario in the year 2020

[a] The analysis is based on Soil-Climate-Land use (SCL) units which are aggregated at NUTS-2 level in order to link them with the CAPRI model.
[b] The analysis is based on 100% of the arable area converted to grassland, the rates are rescaled based on the final converted arable land converted to grassland derived from the CAPRI model (due to the land supply function, the 5% grassland increase is not only coming from the arable land, but as well from other land uses).
[c] The CAPRI baseline incorporates the DG AGRI baseline of 2012 (Fellman and Helaine, 2012) and it incorporates the latest CAP developments, however it does not considered the CAP Post-2013 Reform as the final regulation has not been approved at the time the study is performed.

3. RESULTS

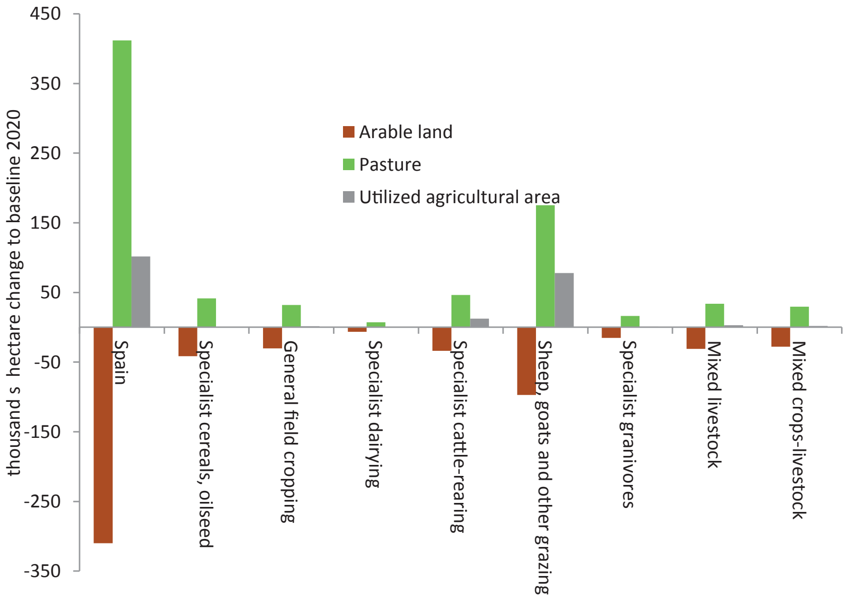
Due to size limitation we present results on land use, C sequestration and the resulting CO_2 price. The change in trade, commodity prices and supply will not be discussed here.

Also, impact on changes (increase of 0.8%) of other GHG emissions from agricultural sources (CH_4 and N_2O, totalling about 37 Mt CO_2eq/yr) cannot be presented in detail.

3.1 Land use

The imposed target increases the total utilized agricultural (UAA) area in Spain by 0.4% (101 thousand hectares); while arable land (ARAB) decreases by 1.78% (310 thousand hectares). 42% of the increased grassland area in Spain is used for sheep, dairy and cattle rearing farming systems (see Figure 1).

Figure 1. Land Use Change in Spain and aggregated farm types.

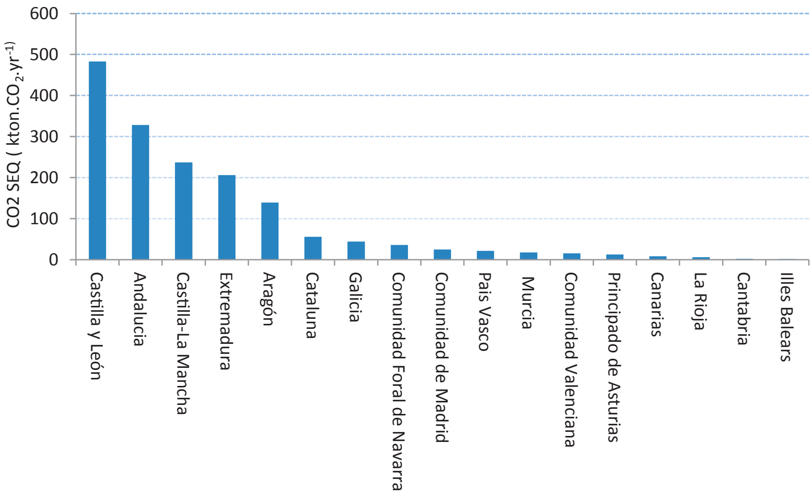


3.2 Carbon sequestration derived from the change in land use

Values of the CO_2 sequestration rates on the soils due to the conversion of arable land to grassland varied (at NUTS2 level) between 3.3 and 9.8 tonnes of CO_2/yr ha in Baleares and Galicia respectively. This variation is related to many drivers such as soil organic carbon content before the conversion, the grassland productivity and the interaction with the projected climatic variables (Lugato *et al.,* 2014).

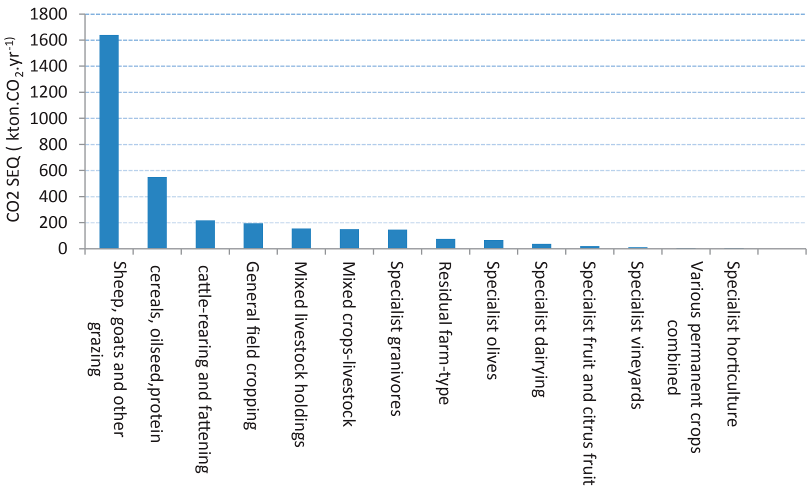
Total carbon sequestration rates at NUTS2 level and farm-types are shown in Figure 2 and Figure 3. They varied between 1 and 253 kt CO_2/yr. Andalucia, Castilla-Leon, Castilla-La Mancha and Extremadura accounts for 76% of all carbon sequestered to the fact that the farm-types with a higher increase in CO2 sequestered (combination of extensive livestock and field crops production as shown in Figure 3) are more abundant in these regions. In total, there was an increase of C sequestration in Spain of 859 kt CO_2/yr.

Figure 2. Average CO_2 sequestered (in kts/yr) at NUTS2 level over the period 2013-2020 derived from the increased in grassland by 5%.



Source: This study.

Figure 3. Average CO_2 sequestered (in kts/yr) at farm type level over the period 2013-2020 derived from the increased in grassland area by 5%.



Source: This study.

3.3 Assessment of the CO_2 price

Table 3. Estimated grassland premium and Cost of the CO_2 sequestered.

NUTS-2	Premium (Euros/ha converted)	Cost of the CO_2 sequestered (Euros/ton CO_2)
Galicia	151	82
Principado de Asturias	356	158
Cantabria	102	34
Pais Vasco	217	67
Comunidad Foral de Navarra	130	43
La Rioja	108	46
Aragón	128	40
Comunidad de Madrid	173	71
Castilla y León	137	39
Castilla-La Mancha	63	24
Extremadura	150	74
Cataluna	83	18
Comunidad Valenciana	135	34
Illes Balears	73	32
Andalucia	157	64
Murcia	53	14
Canarias	844	294
Spain (average)	138	50

Table 3 shows the artificial grassland premium at the NUTS-2 level. The premium calculated in the CAPRI-FT model represents the premium associated to grassland conversion so that farmers increase grassland area up to the total NUTS-2 target value. The premium varied between 53 Euros/ha in Baleares and 844 Euros/ha in Castilla-Leon with an average of 138 Euros/ha.This amount is 1.7 times higher than the average EU-28 agri-environment expenditure for the period 2007-2009 which was 84 Euros/ha (ESTAT, 2012), however it is within the range of the maximum premium per ha established for the "Agri-environment climate" measures in the CAP-Post 2013 (200-900 Euros/ha) (OJEU, 2013a).

For comparison with the potential use of the ETS (European Trading Scheme) for CO_2 sequestered on the soil, we have used the ratio between the calculated premium and the CO_2 sequestered on the soil (Table 3). The average ratio in Spain is 50 Euros per ton CO_2 sequestered in the soil per year (with a range between 14-294). This price is about 11 times higher than the 2013 average price of the European Union Allowance (EUA) of EUR 4.43/ton CO_2 (SEDENCO2, 2013). Considering a setting on the period similar to the "Agri-Environment Climate Change measures" (AECM) (minimum period of 5 years) and that costs are incurred only once[1] the carbon price is reduced to 10 Euros/ton CO_2. This value is similar to the range of values (between 11 and

[1] We are aware that in the framework of AECM the premium is paid annually and based on income forgone. However in the conversion from arable land to grassland there is no significant effect on agricultural income per ha (decrease by 0.06% compared to the baseline) and therefore the income forgone is only related to investment costs on the first year.

35 euros/ton CO_2) determined in a set of scenarios with target reductions on emissions (shared by ETS and non-ETS sectors) between 35% and 45% in year 2030 relative to 1990 (EC, 2014a; EC,2014b).

Unfortunately no study assessing of the marginal abatement cost of converting from arable land to grassland has been found; however other measures related to grassland are assessed in the study by Pellerin *et al.* (2013) in France, including introduction of grass buffer strips (528 Euros/ton CO_2); legumes in grassland (-185 Euros/ton CO_2), grain legumes in arable systems (192 Euros/tonCO_2), increase life spam of grassland (-184 Euros/tonCO_2). In the analysis by O'Brien *et al.* (2014) for Irish agriculture the most similar measure is the introduction of cover crops with a value of 50 Euros/ton CO_2.

4. CONCLUSION

Our results highlights that conversion of arable land to grassland is an effective policy to induce enhanced increase carbon sequestration (in Spain there is a decrease of 859 kt CO_2/yr compared with the baseline scenario). However these results should be taken with caution as there is an increase of CH_4 and N_2O (263 kt CO_2/yr) coming mainly from the increase in grazing livestock and as we are uncertain about potential leakage effects and the permanence of C stock changes in long-term.

In the current setting of the CAP-Post 2013 the "*greening*" payment (OJEU, 2013b) is composed of: crop diversification on arable land, maintenance of the existing permanent grassland and having ecological focus area (EFA). The mitigation policy assessed in this study is more restrictive than the maintenance of permanent grassland, however MS can decide to implement as EFA "the conversion of arable land into permanent pasture extensively used" (5% in 2015-2017 and 7% as from 2018). Apart from EFA the current framework to apply the mitigation policy under study is the "Agri-Environment Climate Change measures" (AECM) embedded in the Rural Development Regulation. The average carbon price estimated in this study is 50 Euros/ton CO_2. This is 11 times higher than the average 2013 daily values of the price of the European Union Allowance (EUA) 4.43

Euros/ton CO_2 (SEDENCO2, 2013); therefore not being a competitive policy. However, it can be indicated that the grassland premium should be paid only once as the cost needed to implement the measure/income forgone is only incurred the first year when changing the land-use. As AECM have a minimum of five years, the average annual carbon prices is reduced to a maximum of 10 Euros/ton CO_2 that it is similar to the one determined in the impact assessment by the European Commission (EC, 2014a and EC,2014b).

Furthermore, maintenance of grassland comes with considerable co-benefits for ecosystem services such as biodiversity (PBL, 2012; Maes *et al.*, 2013) and therefore the 'real' marginal benefit of the net decrease in CO_2 emissions is higher compared to the industry and energy sectors. Indeed, there is evidence that society might be willing to pay for other ecosystem services the measures provide (Rodriguez *et al.*, 2013), thus sharing the total cost.

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