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Impact of climate mitigation policies on the EU agricultural sector in the perspective of Sustainable Development Goals: An integrated modeling approach

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Agriculture is the biggest source of anthropogenic non-CO_2 emissions, being responsible for around 40% of total methane (CH_4), 60% of nitrous oxide (N_2O), and around 10-12% (including CO_2 up to 20-35%) of total anthropogenic greenhouse gas (GHG) emissions (EPA, 2012; IPCC, 2014; West et al., 2014; Tubiello et al., 2015; Smith, 2017). In the European Union (EU), agricultural non-CO2 emissions contribute around 10% (430 $MtCO_2e$) to the total GHG emissions across sectors in 2016. These emissions dropped by over 20% since 1990, mainly through the reduction in livestock numbers and overall efficiency improvements in EU agriculture such as the more efficient use of inorganic fertilizers according to recent UNFCCC data. Even though mitigation of agricultural non-CO_2 emissions is challenging, combining both supply and demand side efforts may deliver emission reductions of up to 50% by 2050 (EC, 2018). Due to the sectors importance as residual GHG emitter following the decarbonisation of the energy system, agriculture's role in mitigation efforts is likely to receive much more attention in the future (Gernaat et al., 2015). As any reduction in agricultural non-CO_2 emissions in the short term will alleviate the burden and need for negative emissions in the second half of the century (Obersteiner et al., 2018; van Vuuren et al., 2018), agriculture will have to contribute in one way or another to the ambitious mitigation efforts across sectors. This was also recognized by the European Commission in its long term strategy and vision to achieve climate neutrality by 2050 (EC, 2018).

In this paper, presenting results of the SUPREMA project, we quantify the impact of various level of ambitions for methane and nitrous oxide emission reduction on top of a harmonized baseline scenario without mitigation efforts across a set of very complementary state-of-the art economic land use and agricultural sector models; the EU level agricultural sector model CAPRI, global agricultural and forest sector model GLOBIOM, and the global general equilibrium model MAGNET. We contrast baseline results to a range of climate change mitigation scenarios in and outside of the EU to explore GHG emission leakage. We test the impact of mitigation action inside the EU that would if pursued at global scale achieve the 1.5 C target. We assess on the one hand implications of a unilateral mitigation policy in the EU only and on the other hand varying levels of mitigation ambition in the rest of the world. Since agricultural markets are connected through international trade regional mitigation policies may impact other regions. As the EU's agricultural sector is amongst the most GHG efficient ones worldwide, the level of mitigation action taken outside the EU is key to assess the impact of domestic mitigation efforts on EU farmers. For example, if ambitious action is taken also in the rest of the world, EU farmers could benefit from increasing exports to regions that produce currently with high GHG intensity.

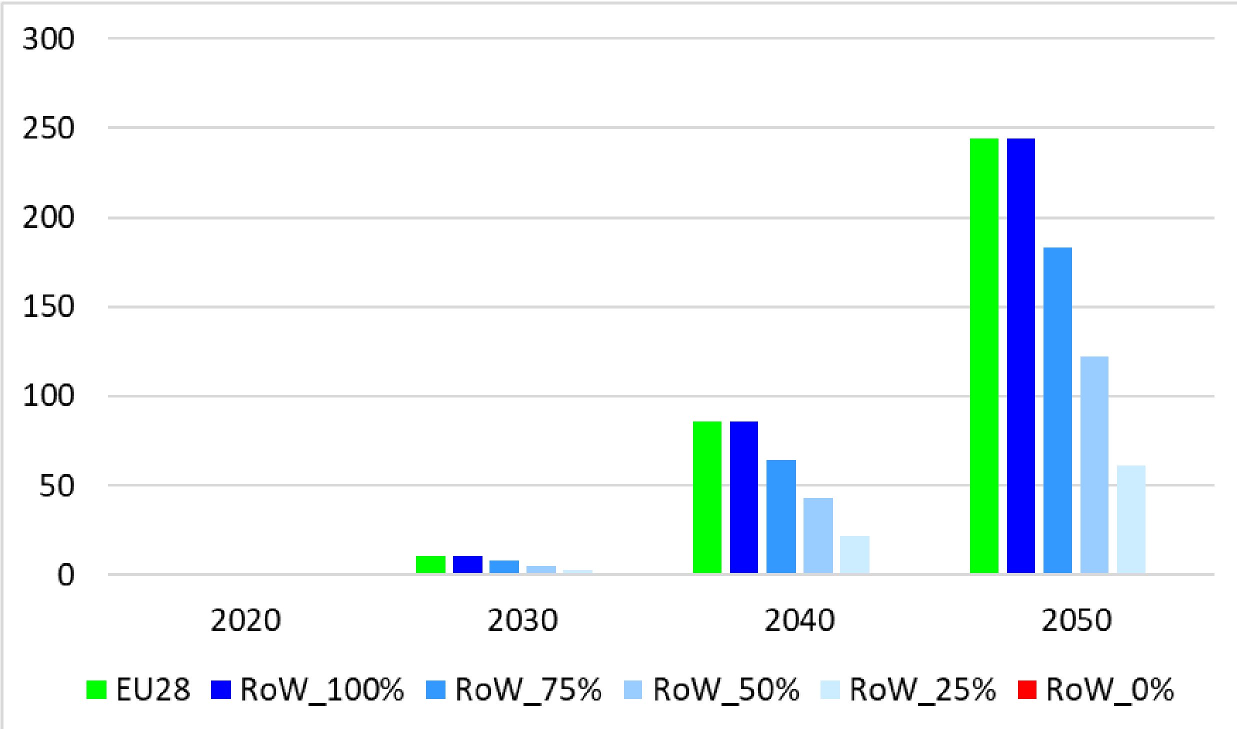

Figure 1. Carbon price trajectories in USD/tCO2eq at different levels of mitigation efforts in- and outside of the EU. In the mitigation scenarios the EU always pursues mitigation efforts in line with the 1.5 C target while for the rest of the world (RoW) different levels of mitigation efforts are assumed.

By its spatial coverage, the integrated modeling framework allowed us to identify counterintuitive effects, such as *i)* unilateral mitigation effort in the EU agricultural sector would lead to increase in GHG emissions outside the EU. However, at global scale, even the unilateral mitigation policy could deliver positive effects.

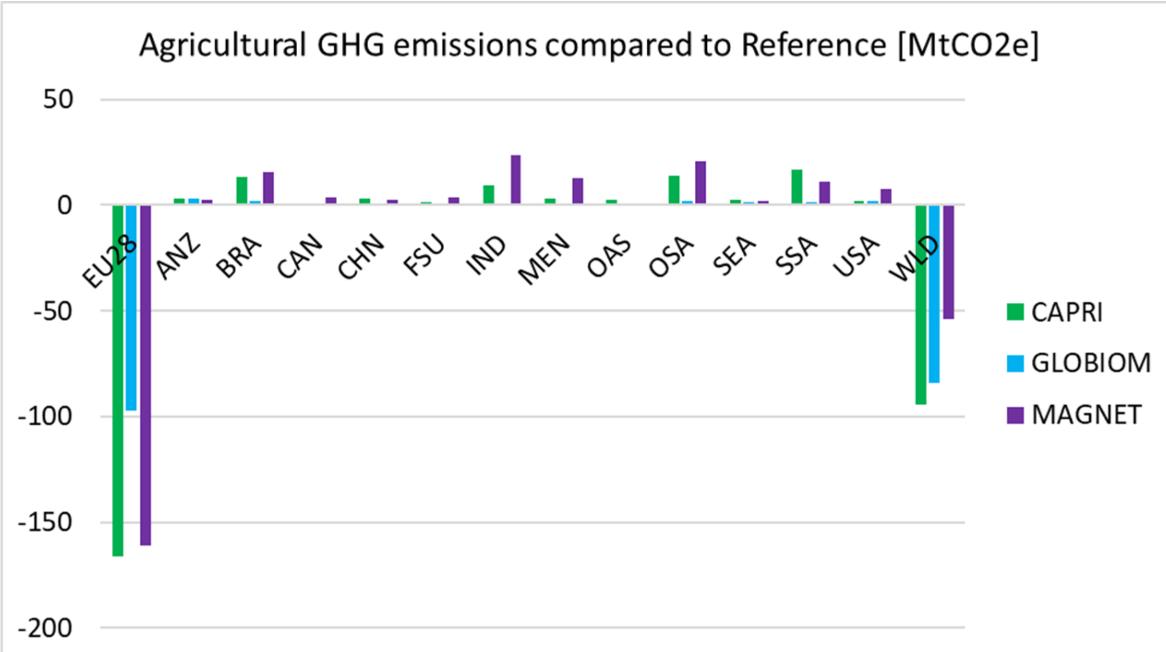

Figure 2. Change in GHG emissions in the unilateral EU mitigation scenario compared to the baseline by 2050.

ii) Inclusive mitigation efforts where also regions outside the EU take action deliver much higher levels of emission reductions. Already a buy-in of the RoW of 25% efforts compared to the EU achieves around 70% of emission reduction compared to the scenario with full buy-in (RoW_100%) and emission leakage can be prevented. Hence, even partial enrollment outside the EU matters.

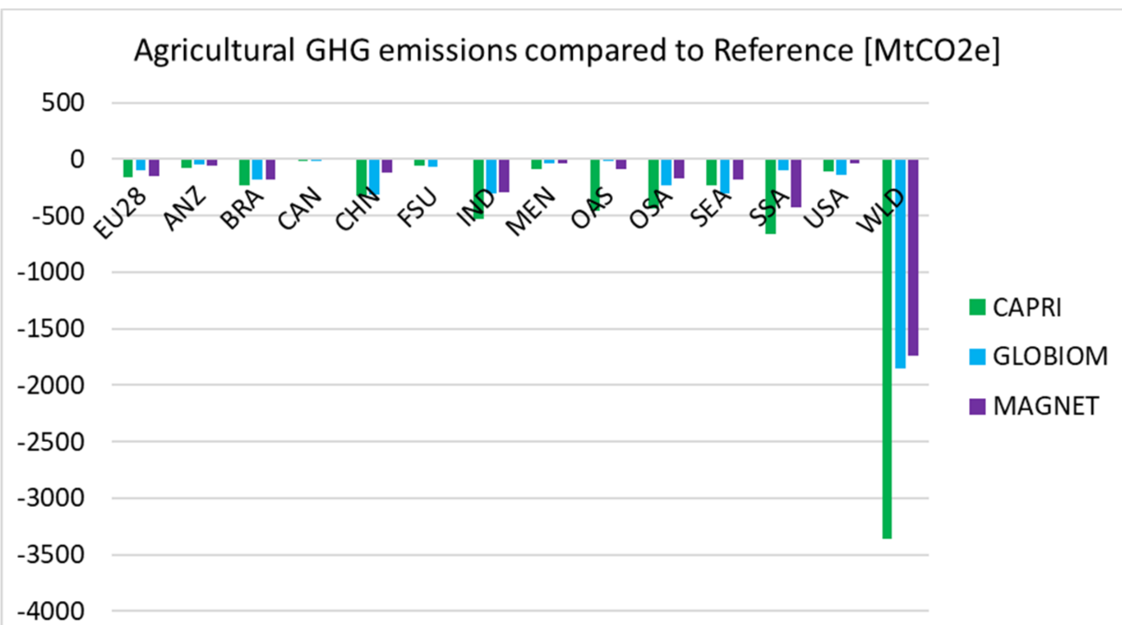

Figure 3. Change in GHG emissions in the mitigation scenario where also the rest of the world takes action (RoW_25%) compared to the baseline by 2050.

iii) A unilateral policy in the EU decreases domestic agricultural production and corresponding emission , in particular for livestock products such as beef, while farmers outside the EU benefit. However, partial enrollment of the mitigation efforts also in regions outside the EU tend to distribute market effects more equally across world regions. Besides market effects, mitigation policies yield also co-benefits for the environment inside the EU.